POWER

Volume 64 New York, August 17, 1926 *Number* 7

Probity to Order

WHEN a condition develops that works an injustice or is offensive to the individual and with which he finds it impossible to cope, his mind turns naturally to collective action—to legislation.

There are many things that must be done collectively—and they are done collectively whether the people chip in to a fund to be expended for the purpose, as when it is a governmental activity, or when they unite in hiring somebody to do it, as in the case of a public utility.

But there are some things that legislation, especially of the "Thou Shalt Not!" variety, cannot bring about.

It cannot make men honest, fair, just, industrious, thrifty, sober.

It cannot imbue the business man with the sense that the legitimate function of his business is not to make big salaries for its officers, big dividends for its stockholders and big wages for its workmen, but to render real service to the people at a return commensurate with the risk and cost involved.

The Seventh Commandment and all the statutes of all the States against stealing will not make a man honest who had no other deterrent and who thinks that he can get away with something without being found out.

Probity, an ethical condition that, if prevalent, would redound to the progress and benefit of the race, is the result of a state of mind, not of the constable's badge or the policeman's club.

What can we do to cultivate it?

Modern Cement Plant Produces All Its Power From Waste Heat

POWER plant consisting of three 10,480-sq.ft. boilers and 3,000-kw. turbo-generator capacity operates on the waste heat from the cement kilns. At times the steam produced in the boilers exceeds the requirements by about 50 per cent. Evaporators and a 35,000-gal. distilled-water storage are used to regulate the heat cycle.

By T. M. Arnold
Electrical Engineer, Southwestern Portland Cement Company, Osborne, Ohio

EVERY engineer who has handled operating problems will concede that American industry still presents many opportunities for the elimination of waste. Waste products can be utilized only as economic conditions render their recovery justifiable at reasonable capital outlay. Fuel conservation has been discussed in great detail during the last few years and has been attacked from many angles with more or less gratifying results.

The waste gases from the rotary kilns in the manufacture of portland cement will contain from 40 to 50 per cent of the original heat of the coal in a well-operated plant. The average plant will require from 90 to 150 lb. of coal per barrel of cement clinker burned. The recovery of this waste heat has received much attention from investigators, but many difficulties required solution before the modern waste-heat boiler for cement kilns came into successful operation.

High Load Factor Warrants Expenditure for High Efficiency

The power plant of the Southwestern Portland Cement Co., at Osborn, Ohio, is an excellent example of what may be accomplished with a plant of this type. When it was decided to build the mill, several principles were laid down for the designing engineers. Some of these were: The quality of the product must receive first consideration; the plant must be substantially built and of pleasing appearance with all equipment conveniently arranged for operation and repairs; the usual dust around a cement plant must be eliminated. As power is usually one of the larger components of the cost in a cement plant, the power plant received intensive engineering study. The plant was designed for continuous operation throughout the year. As a cement-mill power plant has twenty-four hour operation daily, the annual load factor is high. Other plants of the company are operating with annual load factors of 85 to 90 per cent, based on the installed power equipment. This will allow considerable capital outlay for attaining high operating efficiency.

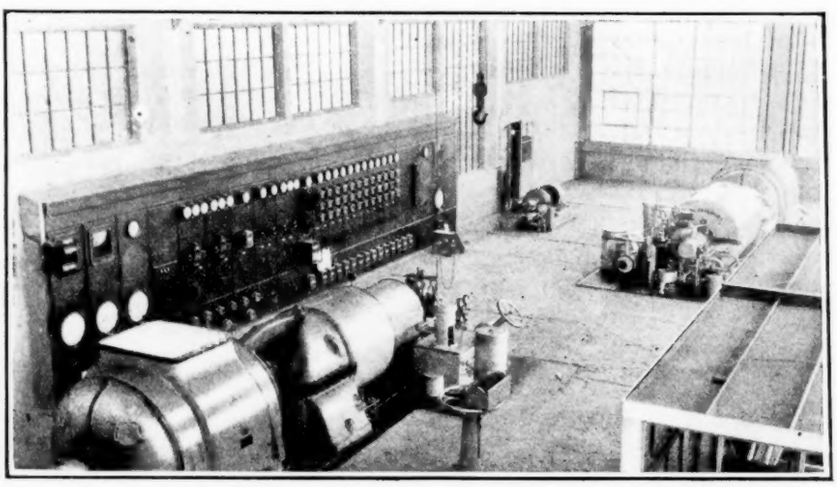


Fig. 1—One 3,000- and one 1,500-kw. turbo-generating unit installed in power plant

Gases leaving the kilns in a cement plant will have a much higher CO_2 content than is usual in boiler practice. In addition to the CO_2 from combustion of the fuel, there is the CO_2 driven off from the limestone. The CO_2 in the dry gases will thus run in the neighborhood of 25 per cent. Nearly perfect combustion can be maintained in these kilns, thus the oxygen content seldom runs above 5 per cent and will average about 2 per cent. Traces of SO_2 and CO are found at times. The evaporation of the water in the slurry injects a large percentage of water vapor in the gases. The mean specific heat of the gases is thus much higher than in current boiler practice.

The quantity of gases handled requires quite large flues. such flues are expensive to build, and air infiltration and radiation losses are more serious with waste heat than with direct fired boilers. The flue system was thus designed to give a short gas travel and a direct passage from the kilns to the boilers. Continuity in operations demanded flexibility in control. Thus the flue system was designed with an equalizer flue between and at right angles with the kilns and boilers. One side of this flue receives the connection with the kiln rear housings and the other the boiler connections. Dampers are provided at these openings to allow any combination of boilers and kilns. From the kilns the gases pass down the rear housing to the equalizer flue and through this to the boilers. Three 10,480-sq.ft. waste-heat boilers, equipped with superheaters and horizon-

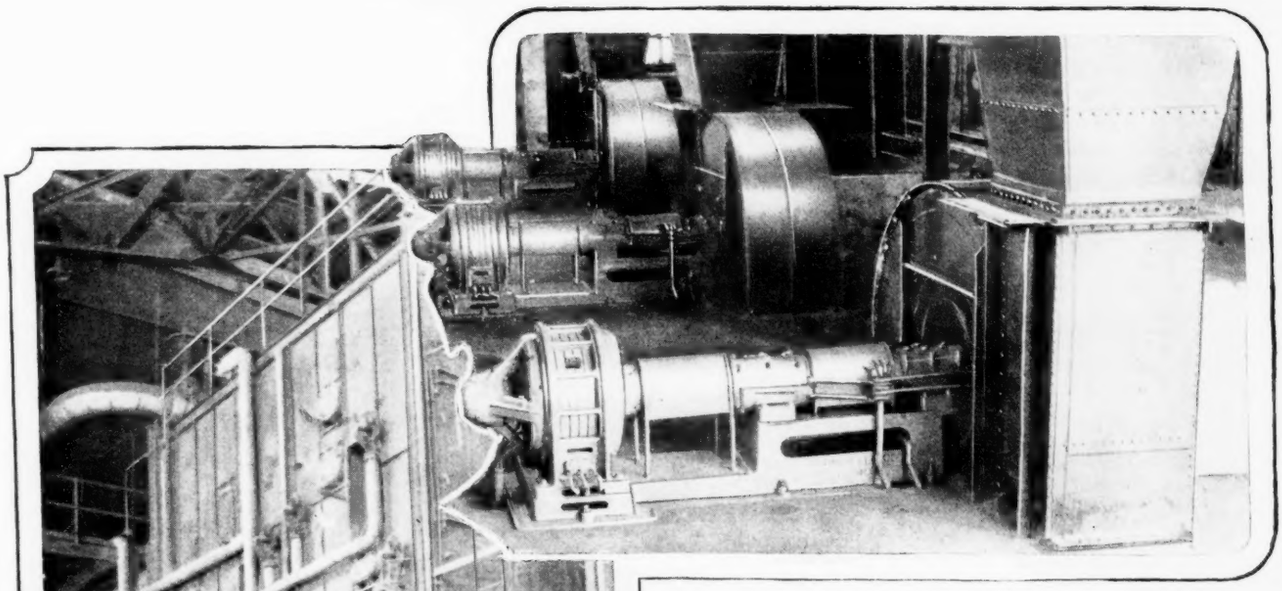


Fig. 2 (Above)—Variable-speed motors drive induced draft fans

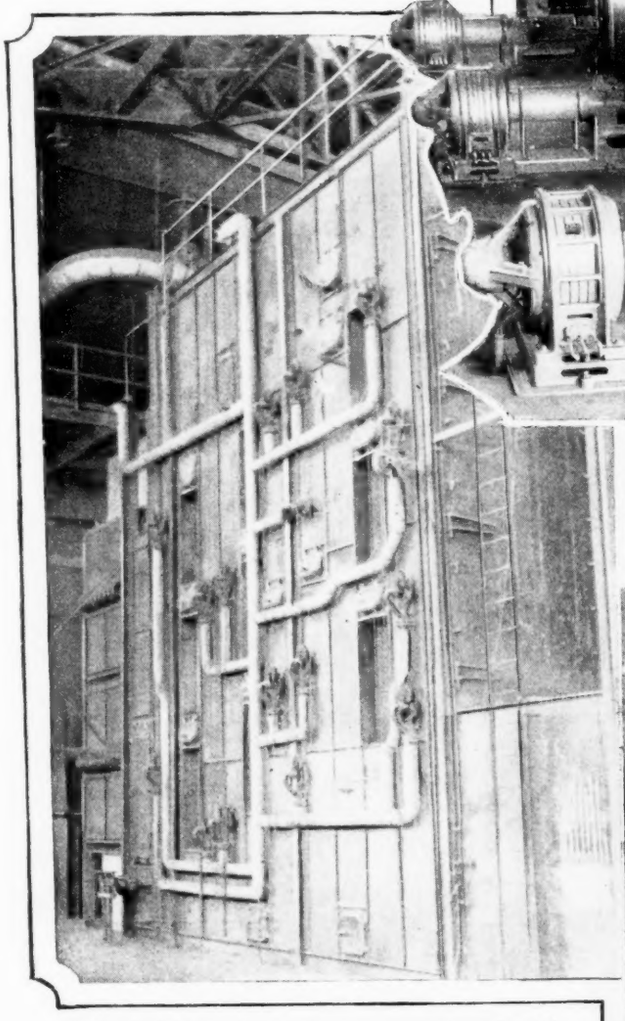


Fig. 3 (Above)—Boilers are equipped with superheaters and economizers

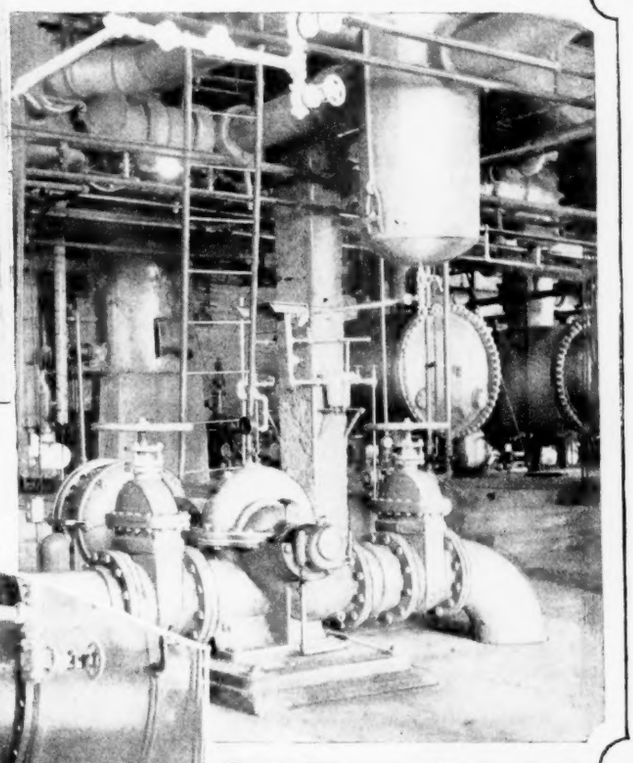


Fig. 4 (Above)—All power-plant piping is below the turbine-room floor

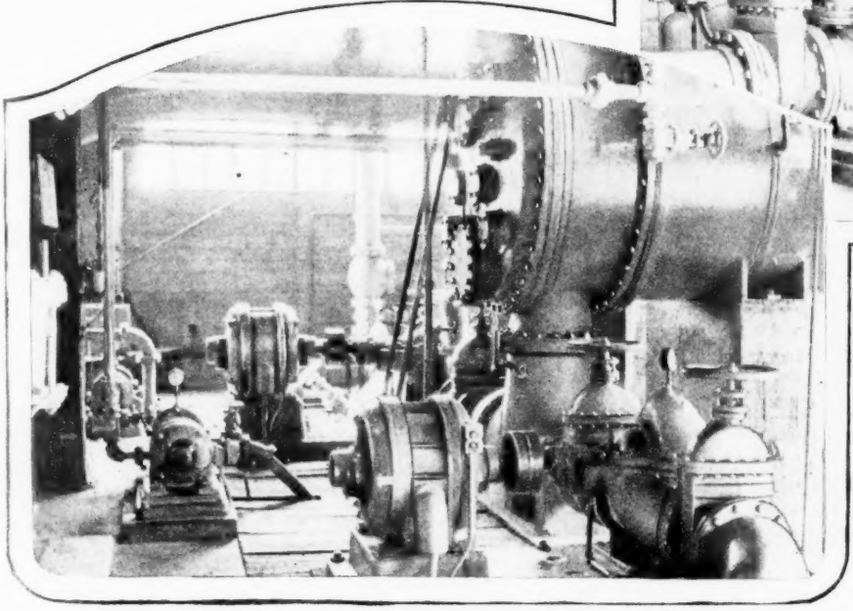


Fig. 5 (Left)—Condenser auxiliary motors have push-button control

tal tube economizers were installed. Draft is provided by means of individual, variable-speed motor-driven induced-draft fans at the rear of each of the economizers. The fans discharge the gases to a flue which conducts them to the electrical precipitation plant. This plant removes the remaining dust and discharges the clean gas to the atmosphere through the stack.

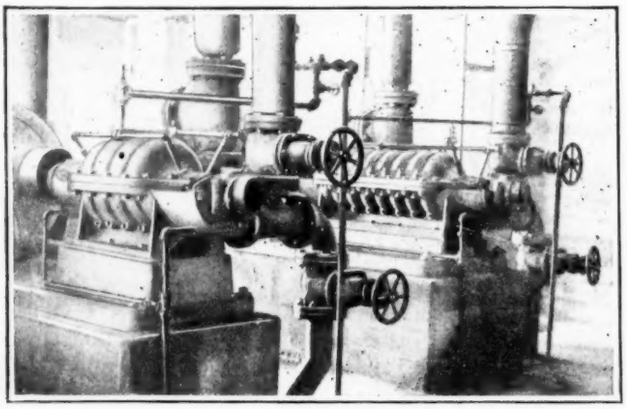


Fig. 6—One motor-driven and one turbine-driven boiler feed pump are provided

To prevent air infiltration and radiation, the flues are steel cased with a layer of insulating brick and a lining of firebrick. Boiler settings are constructed in a similar manner.

The dust in the gases presents a serious problem. The boilers and flues are provided with hopper bottoms throughout to remove the dust accumulations. Soot blowers are provided in the boilers and economizers to remove the dust that settles on the tubes and other heating surfaces.

One motor-driven and one steam-turbine-driven centrifugal boiler-feed pump have been provided. In normal operation the motor-driven pump is used, reserving the steam pump for emergency operation.

Each of the three boilers has a gas capacity ample for the utilization of the heat in the gases from one kiln. Each boiler normally operates in conjunction with its corresponding kiln, but in case of emergency may handle the gases from some other kiln. No spare boilers have been installed, as it is possible to make boiler repairs at such times as repairs are made on the kilns. It is thus possible to operate the boilers over periods of several months duration at full load, provided a supply of pure boiler feed water is available.

Utilizing the Surplus Steam

There are times when a large surplus of steam is available and some provision must be made for utilizing this steam when the full amount of power is not required. The high-pressure evaporators thus serve a double purpose in regulating the heat balance and eliminating scale-forming materials in the boilers. Excess evaporator capacity and hot-well storage capacity for 35,000 gal. of distilled water have been installed. In addition to the distilled boiler-feed makeup, distilled water is furnished for locomotives, locomotive cranes, steam shovels and laboratory use. In the winter the vapor from the evaporators is used for heating the office and plant buildings, the condensate being returned by a vacuum pump. At other times the vapor is condensed in a condenser with water from the circulating water system.

The evaporator vapor and steam bled from the turbines are used to heat the deaërator and the open heater. Normally, all boiler feed water passes through the deaërator. Both steam and water piping is designed on the loop system with at least two sources of supply.

The Generating Equipment

One 3,000-kw. and one 1,500-kw. turbo-generator with surface condensers comprise the generating equipment. Current is generated at 2,300 volts, three-phase, 60-cycles. Direct-connected exciters are used and a spare steam-turbine driven exciter is provided for emergency use. The switchboard is of the electrically operated remote-control type with a dead front. The board is mounted in the wall between turbine and boiler rooms to conserve space. The rear is accessible by means of removable transite doors. The switching equipment is of the cell-mounted type, placed in a room in the basement. Current is metered to each department and is charged in the same manner as are other costs.

Wells provide a plant water supply. The condensing water is pumped to a spray pond approximately 800 ft. from the plant. The generators are equipped with air coolers and for closed-circuit ventilation. Water for cooling is taken from the circulating system.

In waste-heat boilers the heat transfer is accomplished in a different manner from that in a direct-fired boiler. The heat absorption is mainly by convection and conduction. The gas passages are thus longer and the gas velocities much higher than in fuel-fired boilers. In appearance the boilers are high and narrow. The gases enter the boilers at 1,250 deg. F., pass to the economizers at 550 deg. and leave the economizers at 375 deg. Water is fed to the economizers at 180 deg., enters the boilers at 350 deg. and leaves the superheaters at 225 lb. pressure and 150 deg. superheat.

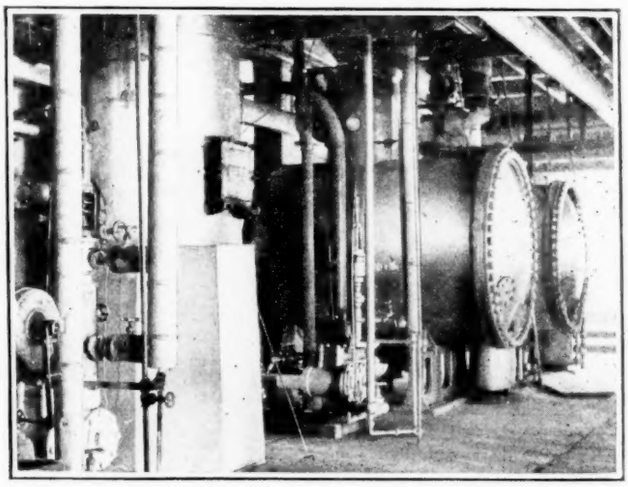


Fig. 7—Below the open-heater and evaporator-room floor is a 35,000-gal. distilled-water storage tank

Approximately 45 per cent of the total heat in the coal, as fired in the kilns, is delivered to the boilers in the gases. Of the total heat, thirty per cent is absorbed in the boilers, 12.5 per cent escapes in the gases and 2.5 per cent is lost in radiation from the flues and boilers. The power production based on the coal burned

in the kilns will vary from 4.5 to 5.8 lb. of coal per kilowatt-hour produced, depending somewhat upon the amount of steam required for distilled water and the amount of boiler blow-off. The latter at times reaches high proportions and has been as much as 50 per cent of the total steam generated. Under some conditions the plant has been operated with two or more blow-off valves open continuously for days at a time.

Five 2½-in. pop valves are used per boiler. These valves are equipped with monel-metal seats, disks and

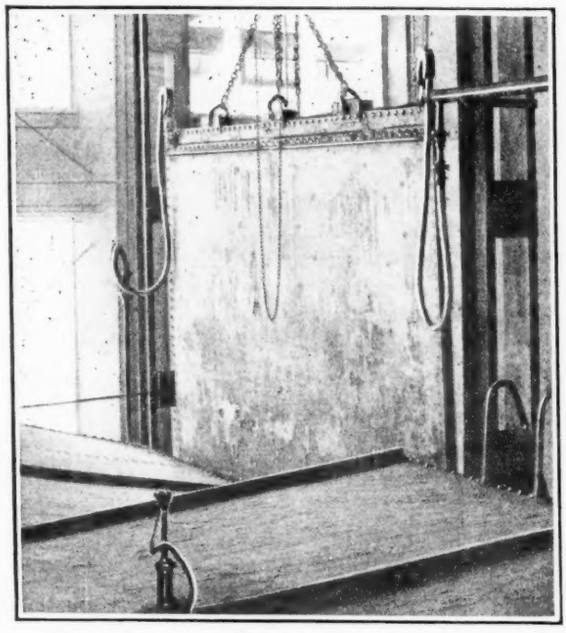


Fig. 8—Water-cooled damper for controlling boiler inlet gases

stems. They are fairly tight after a year and a half of service. They are arranged to open successively as the pressure rises over a range of ten pounds. All the high-pressure steam valves are of 300-lb. rating, cast-steel bodies with monel-metal seats, disks and stems.

Handling the Waste Heat Economically

The usual mental processes of the steam engineer must be completely reversed in handling waste heat economically. The fuel is burned in the kilns to produce clinker and the power department has no control of the amount burned or the heat delivered to the boilers. Power and auxiliary steam consumption must be regulated as nearly as possible to consume the steam as it is generated. The power department is thus forced to accept whatever heat is delivered to it, and to convert this heat into steam. The utilization of the electrical power is in the hands of the mill operating department. Close co-ordination of the various departments is thus a vital necessity for maximum utilization of the heat recovered.

Instruments for observing and recording the various factors that are vital to economic operation have been provided throughout the plant. The uninterrupted flow of the gases and their balance at various points are quite essential to maximum production. Thus, multiple draft gages are installed to measure the draft at the kiln exit, the boiler entrance, the economizer entrance, and the economizer exit. Any obstructions in the passages are thus readily located. For recording gas temperatures, six-record pyrometers are provided for each boiler and kiln unit. Temperature of the gases is taken at the kiln exit, the boiler entrance, the economizers entrance, the economizer exit and at the main-flue connection to the precipitation plant. The steam temperature is also shown on this chart. These records on a single chart allow ready comparison and prompt detection of faulty conditions. Secondary combustion, dust accumulations on the heating surfaces become quite prominent on the charts. Steam-flow meters are provided to record the steam generated by each boiler. The feed water is also metered by a flow meter. Suitable instruments are provided to indicate and record pressures and temperatures where required for convenience in operation or for the calculation of operating efficiency.

The records are designed to summarize the operations to a monthly heat balance. The plant thus operates under test conditions and maintains a high efficiency.

The smaller points have not been overlooked. The turbine condensate is used for sealing water on the glands to prevent scaling. As the condensate is used for condensing in the air-ejector aftercoolers, the temperature averages 120 deg. F. To reduce this temperature, the gland water is passed through a cooler using the raw-water feed to the evaporator for cooling. A continuous bypass oil-filtering system is installed to keep the turbine oil in good condition. Regulators are used on the boiler feed lines. One of the boilers is equipped for conversion to pulverized-coal firing in case of emergency.

The operating force is small in comparison with the output. Three men operate the plant on each eight-hour shift, with a part of the time of one man who draws the dust from the boilers and flues. One repair man is carried on the day shift for minor repairs. The mill-repair forces and the machine-shop forces are available for major repairs.

The design of the power plant as well as that of the mill was worked out by the company's engineers under the direction of W. C. Reith, chief engineer. Construction was under the direction of the company engineers and was done mostly by company construction forces.

In the operation of air compressors it usually happens that oil, carbon and other foreign matters are deposited in the air discharge lines and air receiver. A practical method of cleaning these has been developed by the Compressed Air Society. If a mixture of one pound of ordinary lye and 18 pounds of water is passed into the discharge line at the rate of 60 or 70 drops per minute while the compressor is running, this will clean out all the accumulation on the surface of the pipe and in the receiver, and if the blowoff valve on the receiver is opened, all this foreign matter will be discharged therefrom. This cleaning solution should be used every month or oftener, depending on how much accumulation there may be in the receiver.

Any asbestos sheet packing is suitable for gaskets between cylinder and heads of an air compressor, but the heat of compression and oil will gradually soften rubber packing. In replacing gaskets they should be the identical thickness as furnished by builder, to insure proper clearance between air piston and cylinder heads.

*Boiler Feed-Water Purification—VII**

Where Zeolites Fit In

Effect of Acids and Suspended Solids—Overloading and Improper Handling—Meaning of "Zero Hardness"—Cost of Treatment

By SHEPPARD T. POWELL
Consulting Chemical Engineer, Baltimore, Md.

IT IS essential that water that is to be softened by a zeolite softener shall be practically free from suspended solids. For this reason it is customary to provide a filter for clarification of the water prior to softening. Free mineral acid and appreciable amounts of free carbon dioxide are objectionable also, unless the acidity is neutralized prior to passing the water through the softener.

When the apparatus is operated beyond its designed capacity, the loss of softening efficiency is gradual, but the material will continue to soften the water partly until the sodium content has been largely exhausted. The curves shown in Fig. 1 were plotted from the results obtained by passing water through two zeolite minerals, one a porous and the other a non-porous material. The results showed that both minerals functioned satisfactorily for eight hours, the rated capacity of the softeners. From that time on there was a reduction in the percentage of removal of calcium and magnesium.

The efficiency of these softeners will be influenced markedly by the condition of the beds, the care in regenerating the material and the rate of filtration through the bed. If the bed of zeolite is not backwashed properly, there is danger of disturbing the underdraining system and driving the gravel up into the zeolite. Most softeners are designed to prevent back-washing at excessively high rates.

What "Zero Hardness" Means

The statement is frequently made that zeolite softeners produce water of "zero hardness." By this is meant that the water as discharged from the softener will not contain calcium and magnesium in sufficient quantity to indicate hardness as measured by a standard soap solution. Water softened by a zeolite softener usually contains some calcium and magnesium even when the apparatus is operated at maximum efficiency. It is unfortunate that the term "zero hardness" has been adopted by all manufacturers of these appliances, since many engineers interpret this phrase literally and believe "zero hardness" to indicate complete removal of calcium and magnesium.

Carefully controlled tests by the author in which the water was passed through the zeolite bed at low rates, showed that it was not possible even under the most favorable condition to eliminate completely at all times calcium and magnesium from the water after passing through porous and non-porous minerals. The result in actual operation showed much greater amounts of these salts present in the effluent from the softeners.

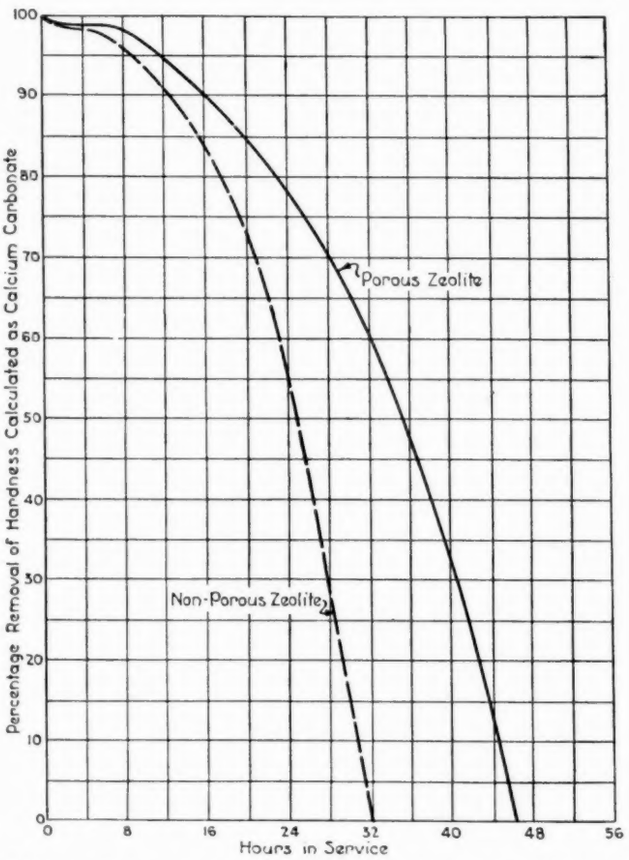


Fig. 1—Reduction in efficiency of zeolite water-softening materials due to overloading

The curve plotted in Fig. 2 indicates the amount of hardness in the softened water from porous and non-porous base-exchange minerals. The accompanying table shows the results of analyses of water from a number of zeolite softeners. The samples were taken from softeners manufactured by different concerns and treating water varying in hardness.

The small amounts of calcium and magnesium that pass through these softeners are unobjectionable. When properly operated, this system will prevent scale forming in boilers, and practically no deposits will accumulate if blowing down of the boiler is controlled properly.

*Previous installments have covered the following subjects: July 6, "Natural Waters and Their Impurities"; July 13, "Getting Rid of Impurities by Sedimentation and Coagulation"; July 20, "Filtration by Gravity and Pressure Filters"; July 27, "Softening Water by Chemicals"; Aug. 3, "Hot-Process Continuous Softeners"; Aug. 10, "Zeolites Explained." The last-named article showed how the sand-like "base-exchange" silicates termed zeolites, soften water by exchanging sodium for the calcium and magnesium in the scale-forming solids. The process of regenerating the zeolite with a brine of common salt was also described, as well as the construction and operation of typical zeolite softening systems.

The increase in evaporation due to scale prevention effected by softening the water by a zeolite or other system is frequently quite marked. In Fig. 3 is shown the evaporation of pounds of water per pound of fuel for twelve months before and after softening the water by means of a zeolite softening system.

When soft water is used in boilers that contain old deposits, care should be exercised to remove the deposits that will be loosened from the tube owing to the action

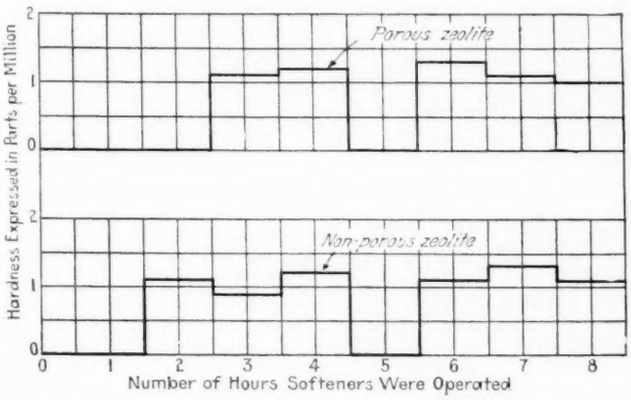


Fig. 2—Hardness of water softened by porous and non-porous zeolite materials

of the soft water. This may necessitate an increase in blowdown for a few weeks after the system is first put into operation. After the scale has worked out of the boiler, the blowdown may be reduced to normal and even lower.

Cost of Treatment

The cost of operation of zeolite softeners is affected mainly by three factors—(a) the hardness of the raw water, (b) the cost of salt and (c) the efficiency of the system. Other items of expense enter into the cost of treatment, but these are more or less uniform at different installations. The cost of the zeolite water softening of the feed water at the Spring Garden plant of the Consolidated Gas, Electric Light & Power Co., of Baltimore, was 4c. per 1,000 gal. of water treated. Since the raw water during the period covered by this statement averaged about 3 grains of hardness per gallon of water, the cost of treatment was 1.33c. per grain of hardness removed per 1,000 gal. of water treated. This plant has a normal rated capacity of 220,000 gal. per 24 hours and cost installed $13,000. The itemized annual and fixed charges are given herewith.

Operating labor	$803.00
Maintenance	100.00
Water used for back washing filter	230.00
Salt	585.00
Interest, taxes and depreciation	1,560.00
	$3,278.00

Comparison of Chemical and Zeolite Softeners

A comparison of chemical precipitation softeners and zeolite systems appears desirable since they are sold frequently on a competitive basis. A cold lime-soda softener will reduce the hardness of water to from three to five grains and hot softener from one to three grains. A zeolite system may completely eliminate the total hardness or the softened water from such system may contain as much as 1 to 1½ grains of hardness. Chemical precipitation softeners reduce the soluble solids.

When the hardness in a water is due to bicarbonate only, lime alone is required to soften it and the process will cost not much more than half the cost of treatment by a zeolite system. Water that contains high amounts of sodium salts in addition to calcium and magnesium may be softened more satisfactorily by chemical softeners than by a zeolite system, especially where barium is employed to remove the non-carbonate hardness.

A zeolite system is operated generally under pressure so that the soft water may be discharged into the head tank or storage tank without repumping, the only drop in pressure resulting from the friction losses in passing through the bed of zeolite. Chemical precipitation

TYPICAL ANALYSIS OF WATER FROM ZEOLITE SOFTENERS

Constituent	Results Expressed in Grains per Gallon						
	1	2	3	4	5	6*	7*
Calcium carbonate	0.32	0.27	0.18	0.41	2.9	0.23	1.32
Calcium sulphate	0.16	0.00	0.12	0.20	0.00	0.00	0.00
Magnesium carbonate	0.11	0.06	0.19	0.16	0.8	0.76	0.12
Magnesium sulphate	0.09	0.17	0.00	.....	1.4	.....	0.00
Magnesium chloride	0.00	0.00	0.00	0.19	....	.....	.....
Silica	0.32	0.09	0.18	0.40	0.19	0.96	7.41
Iron and aluminum oxides	0.12	0.10	0.16	0.21	0.01	0.23	0.09
Sodium chloride	0.64	0.20	0.34	0.34	0.54	3.56	0.96
Sodium sulphate	1.84	1.19	2.12	8.40	0.98	18.07	5.38
Sodium carbonate	2.12	3.66	4.18	16.12	2.36	18.13	4.77
Total solids by evaporation	6.12	5.78	8.14	28.03	8.99	46.5	20.27

* Analyses not made by author.

softeners of the continuous type may be operated constantly, while the majority of the base-exchange softeners must be cut out of service for reconditioning for periods of from four to eight hours. In order to insure a constant supply of soft water from the latter, it is necessary to provide storage of treated water or to

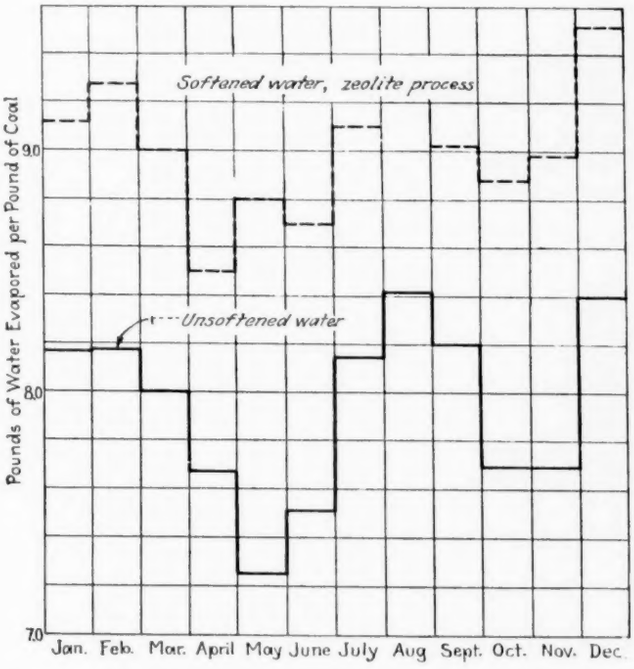

Softened water, zeolite process
Unsoftened water
Pounds of Water Evaporated per Pound of Coal
9.0
8.0
7.0
Jan. Feb. Mar. April May June July Aug Sept. Oct. Nov. Dec.

Fig. 3—Curves showing average evaporation per pound of coal in a large central station before and after using zeolite softener

have the units in duplicate, one being regenerated while the other is in service. This does not apply, however, to those zeolites that may be regenerated instantaneously.

Some systems have been installed that are combination chemical precipitation and zeolite softeners. The object of this arrangement is to remove the carbonate hardness by precipitation with lime, depending on the

zeolite to eliminate the residual carbonate and the non-carbonate (sulphate) hardness. This scheme has been applied with success at a number of places. It is adaptable to water containing high carbonate hardness and also non-carbonates. Since a design of this kind is really two systems, the cost is increased materially over a single system. Where a lime-zeolite combination is used, the treatment must be carried out in cold water since base-exchange mineral disintegrates in hot water.

The effect of high concentrations of sodium salts in boiler water has been discussed at length in the technical press frequently. There are many who claim that sodium salts have no detrimental effect on boiler operation even in high concentration. Others hold to the opinion that sodium compounds are responsible for practically all foaming or priming in boiler water, are highly corrosive and are the principal cause of embrittlement of metal. Discussions on the subject which have appeared from time to time are fraught with biased opinion, and frequently the conclusion is one not supported by sufficient proof to be of value. The effect of sodium salts in boiler water will be reviewed in a later article. High amounts of sodium salts are objectionable and must be controlled. This may necessitate excessive blowing-down of boilers, resulting in high heat losses.

There are a number of specific advantages and disadvantages of zeolite water softeners which may be summed up briefly as follows:

Advantages of Zeolite Softeners

1. Practically complete removal of lime and magnesia salts from the water.
2. Less supervision generally than lime-soda softeners.
3. No chemicals are added to the water.
4. The softener may be placed on the main supply line and will cause practically no loss of pressure.
5. No repumping of the softened water is required.
6. No appreciable amount of scale will deposit in the boilers.
7. The system will operate efficiently with fluctuating hardness of the untreated water.
8. This type of softener may be used to advantage to deliver water of practically zero hardness when operating on a very hard water, if the water is treated first by a lime and soda softener.

Disadvantages of Zeolite Softeners

1. Zeolite softeners cannot operate efficiently on turbid waters or waters containing appreciable amounts of iron and manganese, unless such waters are treated first to remove these constituents.
2. These softeners cannot be used to treat waters containing free acid, unless the acid is first neutralized.
3. Zeolite softeners cannot be operated economically with waters of high hardness.
4. Increase of sodium salts is proportionate to the lime and magnesia salts contained in the raw water supply.
5. There is a tendency of boiler water to prime or foam, unless the boilers are blown down sufficiently well to prevent high concentration of soda salts.
6. An increase generally in the amount of water required for blowdown of the boilers in order to control the concentration of soluble salts.
7. There is some loss of zeolite, due to attrition.

The cost of operation of a base-exchange softener will vary with a number of factors. A water that is clear will not require filtration prior to softening, and the operation of such a system will be substantially less than where filtration is necessary. The cost of salt affects the purification of the water greatly, since it is the principal item of expense. Since the salt consumption is in direct proportion to the hardness of the water, the cost of operation will vary directly with the amount of calcium and magnesium contained in the water.

Use Intelligence In Oiling Bearings

By L. A. Cowles*
Chief Engineer, University of South Dakota

A LARGE part of the energy applied to a shaft is wasted in overcoming frictional resistance. Practically all of the wear is due to this, and there is no doubt that incorrect application of lubricants is the cause of many a burned bearing, excessive wear and loss of energy. Not until lubricating specialists had called at the plant for several years, did it occur to the author that he did not know what they were talking about half the time and that he should know enough about lubrication to enable him to judge the value of the products offered for sale. This led to a study of oil, and a more interesting subject would be hard to find.

Friction vs. Cohesion

To select the correct lubricant it is necessary to consider why it is used and the results that may be expected under various conditions. Friction is caused by the sliding or rolling of substances over each other. Theoretically, the harder and smoother the surfaces the less force is needed to move them. As what may appear to be a perfectly smooth surface is really a succession of minute mountains and valleys, the conclusion has been reached that hard polished surfaces make the ideal bearing. This would be true were it not for cohesion. As the friction loss is reduced by the smoother surfaces, the resistance to motion is increased by cohesion.

It has been demonstrated that pieces actually can be welded together by compression of carefully prepared sections. This tendency is more pronounced at an increase in temperature.

Temperatures

In a bearing the heat generated is in proportion to the energy expended in overcoming the resistance to motion. Therefore, bearing temperatures measure the bearing friction. It must be considered that this heat is carried away to a great extent by conduction, radiation and convection, so that a high temperature indicates an appreciable loss.

Viscosity, as used by the oil trade, is the measure of the flow of oil through a standard orifice at a given temperature. Also, it may be considered the resistance to separation of the particles of oil. The viscosity lowers as the temperature rises, that is, the oil becomes thinner. It may reach such a temperature that, in the case of a mineral oil, it does not separate the metallic surfaces. Animal oil at high temperatures will decompose.

The prevailing idea that a heavier oil must be used

to reduce bearing temperatures is erroneous. If the viscosity of the oil is too high for the bearing, the temperature will rise until the viscosity is reduced, and a balance between friction, oil film and heat conducted away is reached.

Lubrication of High-and-Low-Speed Journals

Lubrication of slow-speed journals is often more of a problem than that of high-speed bearings, owing to the fact that the oil film is not sustained by a liquid pressure because of the rotation of the shaft, and must depend upon the combined capillarity and viscosity, or body, of the oil. A lubricant of animal or vegetable oils may seem to reduce friction when starting, but as the speed increases and the oil film increases in thickness, the friction will increase. A mineral oil of the same viscosity will reduce the friction below that of the animal or vegetable oils.

While a flood of oil is required on a high-speed shaft, it does not seem to be necessary on the slow-turning shaft. As the load increases or the speed decreases, the viscosity, or body, of the lubricant, must increase, emulsions of oil soap and water for heavy-load, slow-turning shafts finally giving place to a combination of plastic and solid lubricants such as grease and graphite or mica. The solid lubricant fills in the valleys of the bearing and prevents welding of the metals under friction.

In high-speed lubrication the oil film is maintained by trapping the oil in between the surfaces. As the speed rises, the oil film increases in thickness until the clearance is filled with the oil and the shaft practically floats on the film. Reducing the viscosity of the oil allows the journal speed to go up another notch without increasing the friction load.

The friction of a journal does not increase in proportion to the load so long as the turn of the shaft maintains the oil film. The greater wear per turn of the shaft is experienced at starting before the oil film has been built up. Considering the friction losses, the viscosity of the oil must be as low as possible and still maintain the oil film; considering bearing wear, the viscosity must be high enough to separate the bearing surfaces at low speed. It is evident that the choice will have to be between the two losses.

A casual observer might suggest at this stage that crankpin bearings should be supplied with a heavier oil than the main bearing, because of the blow to the crank and bearing when changing direction. This is not the case, as the oil is trapped and cushions the shock. The same things must be considered for any rotating shaft, namely, load, speed and temperature.

Oil Films and Oil Grooves

The pressure of the oil film varies with the load, but is independent of the turn of the shaft, although the film is not established until the shaft is turning. The high-pressure and the low-pressure point will vary with the speed of the shaft. Usually, a properly adjusted bearing will pump oil into the bearing space. The importance of the head or pressure of the oil supplied to a bearing in relation to the clearance is evident, as the film pressure at the point of entry may be above that of the oil supply. Taking up on a bearing may so reduce the clearance that unless the oil is supplied to the bearing under pressure, the film is not established.

Cutting oil grooves for the distribution of oil should be done carefully. A groove cut at the point of high film pressure destroys this film, and there is some question as to whether it is re-established. Grooves cut to the end edges of bearings are detrimental, as they will drain the oil from the bearing.

On one occasion the author found a turbine bearing with oil grooves guiding the oil out of the bearing. The grooves were filled up and the bearing scraped so as to leave slightly more clearance from the point of oil entrance and wedge-shaped past the high-pressure area. This bearing then ran 15 deg. cooler and the vibration was reduced.

Longitudinal grooves parallel with the axis of the shaft, have little value except when located at the low-pressure point and used for the distribution of the oil to spiral or V-shaped grooves. V-shaped cuts with the point of the V at the oil supply and the ends pointing in the direction of rotation, aid materially in the distribution of the oil as well as the pumping action of the journal. The grooves need not be cut deep, preferably tapering out at the ends, and their edges must be scraped down to form a wedge for trapping the oil.

Adjusting Bearings

In adjusting bearings for wear, some definite method of ascertaining the clearance should be used. Connecting-rod bearings can be pulled up safely until the bearing cannot be moved by hand. By testing with an 8-in. lever, 1½-in. fulcrum, it should be possible to move the brasses back and forth on the crank or crosshead pin. This freedom of movement should be tested at four points of travel. The main bearings can be taken up by hand while running—that is, using no wrench—and the clearance ascertained by the amount of oil carried into the shaft and the sound of the bearing.

An excellent method of finding a loose bearing is to feed it cylinder oil, the knock decreasing as the heavy oil is taken in. This method was used in locating the cause of excessive vibration on a turbine, the vibration disappearing as the heavy oil entered the bearing. The supposition, in this case, was that the bearing was not supporting its share of the load. A change in the center of gravity by raising the generator end ½ in. corrected the trouble. Although other factors entered into the problem, the heavy oil test put us on the right trail.

When Steam Expands in stationary blades or nozzles, the heat energy lost is turned into kinetic energy, that is, energy of motion. The steam picks up velocity at the expense of heat in the same way that a falling body picks up velocity at the expense of height. The formula for the velocity of a body falling from rest is $V = 8\sqrt{H}$, where V is velocity in feet per second and H equals height fallen in feet. If for H is substituted 778 × heat drop per pound, this formula gives the velocity of expanding steam. It will be noted that the constant 778 is the number of foot-pounds in one heat unit. Another way to look at it is to think of the steam as falling a vertical distance of 778 ft. for each B.t.u. lost. Thus a heat loss of 100 B.t.u. per pound would be equivalent to a fall of 77,800 ft., and the corresponding velocity would be $8\sqrt{77{,}800} = 2{,}230$ ft. per second.

The Difference Between the Heat Content of dry saturated steam at 200 and at 199 lb. per sq.in. abs. is 0.1 B.t.u. per lb. Between 2 and 1 lb. per sq.in. abs., this difference is 10.6 B.t.u. per lb. This is a partial illustration of why accurate measurement is usually much more important with low pressures than with high.

Bucket Conveyors and Storage Equipment

By W. W. SAYERS
Chief engineer, Link-Belt Company, Chicago.

STATUS of the pivoted-bucket carrier for coal and ash handling. Hoisting towers are suitable for water-borne coal, but only when the tonnage is high. Use of the locomotive crane, central store system and bridge tramways for unloading and storing coal. This is the fourth of a series of five articles on coal handling. The first, entitled "Modern Methods in Coal and Ash Handling," appeared in the July 27 issue, the second, on "Elevators and Conveyors for Coal Handling," in the August 3 issue and the third, discussing "Belt Conveyors and Skip Hoists," in the issue of August 10.

PIVOTED or gravity bucket carriers are so called because each bucket is pivotally suspended between two strands of chain and maintained in the carrying position by gravity, thus permitting the bucket to carry its load either horizontally or vertically until it is tilted or turned by mechanical means on a horizontal run for discharging its contents. Long-pitch chains of 18, 24, 30 or 36 in. are used, with buckets of considerable size. The chains and buckets are carried by rollers which in modern equipment are usually of the inclosed self-oiling type, reducing the friction and required power to a minimum **Fig. 1** shows a typical installation.

These carriers operate at slow speeds, 40 to 70 ft. per min., and have capacities of from 20 tons of coal per hour, with 18x18-in. buckets, to 300 tons per hour, with

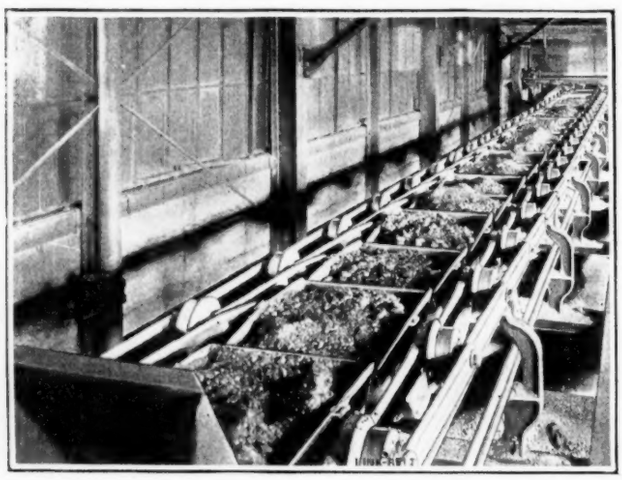


Fig. 1—Typical installation of pivoted-bucket carrier

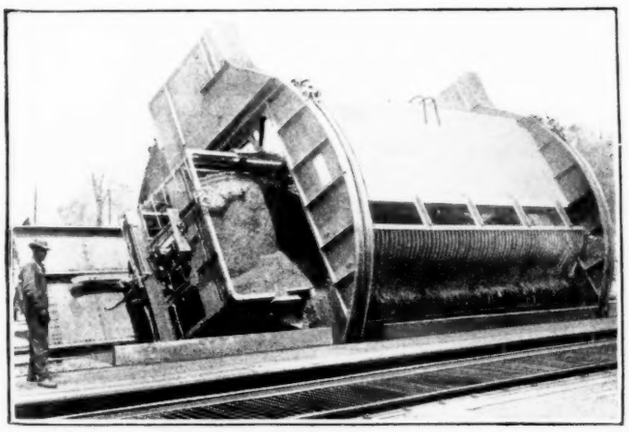


Fig. 2—Gondola car dumper

buckets 36 in. long by 36 in. wide. The buckets usually are made of malleable iron, with overlapping lips to prevent the material from spilling between the buckets and to form a continuous trough for recovering the material. Ordinarily, they are loaded on the lower horizontal run and the material is carried to the up corner, elevated, conveyed along the upper horizontal run and discharged into overhead bunkers or storage bins, or onto other conveying mediums for distribution.

As the buckets carry their load, they are well suited for handling either coal or ash. A large majority of installations are used for both purposes, with the desirable feature that a single unit takes care of both requirements. The feeling by some engineers that a single unit will not satisfactorily and economically handle both coal and ashes, has been demonstrated by many actual applications to be unfounded. The many advantages of the pivoted bucket carrier has resulted in its wide adoption, and the design has been developed to a high standard of construction and workmanship.

Reducing Joint Wear

Long-pitch chains use a minimum number of articulation joints, and usually these are provided with large casehardened steel pins in the outside side bars and casehardened steel bushings in the inside side bars, to prevent any movement except the turning movement between the pins and chain bushings in passing around the sprockets. These bushings also provide a hardened surface upon which the rollers turn. The rollers are cast with chambers for oil reservoirs and provided with special feeding devices for automatically lubricating the surfaces between the roller and the chain bushing and the inside of the bushing and the pin.

In addition to having the rollers cast with chilled tread for reducing the wear between the tread and the rails, the bores of the rollers are provided with renewable casehardened steel bushings, in order to prolong the life of the bore equal to that of the chilled tread.

The selection of the pivoted-bucket carrier for use in modern boiler houses is attributed to the following factors: A single unit in many cases can be employed for handling both coal and ashes. The material handled is always carried, and the buckets are made of malleable iron, with the result that maintenance is low. The construction of the articulation joints, using case-

hardened pins and bushings, large diameter inclosed-oiling rollers with chilled treads, minimizes wear, friction and maintenance.

In many installations a pivoted-bucket carrier, because of suitability for handling both coal and ashes, costs less than the several units of other types necessary for performing the same functions. In other cases, the first cost may be more, but over a period of years the low power requirements, low maintenance and the dependability of operation are factors that will tend to pay large dividends on the additional investment required.

Water-Borne Coal

Water-borne coal is received usually in barges or ships, to be unloaded at the power plant. For unloading these vessels a mast and gaff was used in the early days, but as the barges and ships became larger and had to be unloaded quickly, the hoisting tower was developed. These towers are provided with grab buckets for elevating and discharging the coal into an overhead hopper for distribution. Frequently, these towers are arranged so that the grab bucket can be hoisted and then trolleyed horizontally for discharge direct to the overhead bunker or storage.

Modern hoisting towers have capacities ranging from 100 to 400 tons per hour, making it possible to unload quickly large ships with cargoes of from 4,000 to 6,000 tons. With the larger vessels several hoisting towers are used for the unloading operation.

The Problem of Storage

More attention is being given to providing suitable ground storage, to take care of interruptions to the usual course of supply, due to a bad weather and labor disturbances. Where only a small space is available for storage, portable types of elevator and conveyor are used extensively, and answer the purpose extremely well, as their first cost is low and their adaptability and ease of moving from one place to another make them a valuable type of equipment for the smaller plants.

A large percentage of the coal is received in cars, from which it is dumped or unloaded into track hoppers and delivered to the crushers or conveying units. Track hoppers should be of sufficient size to permit the coal to be dumped at such a rate as will insure a constant supply to the feeding units.

For power plants using several hundred tons of coal per day, received in railroad cars, gondola car dumpers are used to advantage. The cars are placed on the dump, turned over, and their contents discharged into the track hopper, as indicated in Fig. 2. These dumps

Fig. 3—Circular store system using long radius crane

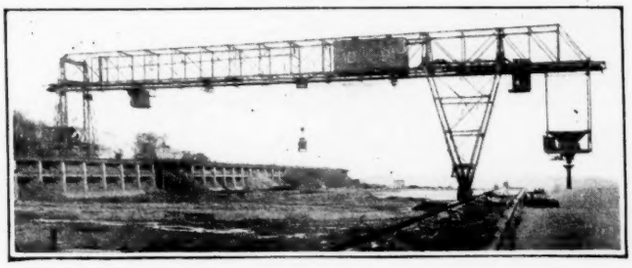


Fig. 4—Bridge tramway for unloading and storing water-borne coal

can unload coal at the rate of one car, of 50 to 90 tons capacity, per minute. It makes no difference whether the cars are of the fixed or hopper-bottom type.

At some plants locomotive cranes provided with grab buckets and, ordinarily, with booms approximately 50 ft. long, are used for unloading the coal into storage and reclaiming it from storage.

For larger coal-storage installations the "circular store system" is used to advantage. It consists of two through tracks, with hoppers under and between them, into which the coal is dumped from the cars. A long-radius crane, equipped with a grab bucket as in Fig. 3, digs the coal from the hopper pit or pits, and transfers it into storage or reclaims the coal from storage. The crane travels on circular tracks of 110 ft. radius from the center of the digging pit or pits.

Each storage pile has a capacity of approximately 60,000 tons or less, depending on the depth to which it is stored. A single crane will serve any number of hoppers or digging pits, so that the total storage capacity is limited only by the trackage and ground available. These cranes are capable of handling coal at the rate of 200 tons an hour.

Bridge tramways are sometimes used for unloading, storing and reclaiming the coal in the manner shown in Fig. 4. They are well adapted for handling water-borne coal, where most of the coal is delivered to storage before using.

The power hoe or drag scraper is used quite commonly for storing and reclaiming coal. The coal is unloaded into an initial pile and distributed by means of a power hoe, which spreads it over the storage area. It also reclaims the coal and delivers it to a track hopper or elevating medium. The drag scraper is well suited for irregular ground areas, or where the quantities handled are not sufficient to justify the investment required for installing more expensive equipment.

The Successful Operation of a low-pressure oil engine depends to a great extent on the action of the fuel nozzle. The check valves must not leak and must close and open rapidly. At least once every 30 days, if the engine is in constant service, the nozzle should be removed and cleaned. Kerosene or strong lye water is by far the best cleansing agent to use. The interior of the nozzle should be inspected and all coke or carbon deposits completely removed. After the nozzle is cleaned, it should be connected to the pump line, although not inserted into the cylinder, with the tip removed. Kerosene should be supplied to the pump, and a pint or so should be forced through the discharge line and the nozzle. This will cleanse the line and nozzle of any small particles of grit or dust.

Power-Factor Correction and How It May Be Accomplished

By H. W. TERRY

THERE are five ways in which power factor may be corrected: Rearrangement of induction motors, use of static condensers, installation of synchronous condensers, installation of synchronous motors and the installation of self-excited induction-synchronous motors. Each of these methods is considered.

ON ALTERNATING-CURRENT systems the power factor may be defined as the ratio of the true power (kilowatts, as indicated by the wattmeter) to the apparent power (kilovolt-amperes, as calculated from the voltmeter and ammeter readings)—that is, *power factor = kilowatts ÷ kilovolt-amperes.* Further, when the current is in step with the voltage, the kilowatts and kilovolt-amperes are equal, in which case the power factor equals unity, or 100 per cent. In all other cases the kilovolts will be greater than the kilowatts and the power factor will be a decimal, or less than unity.

It is difficult to make a general statement as to the expected over-all power-factor that will be obtained in a plant driven entirely by induction motors, as this depends largely upon whether the motors are operating at approximately full rated load or lightly loaded. An over-all power factor of 80 per cent may be looked upon as unusually good, while power factors of 60 and 70 per cent are typical of the majority of cases. Frequently, conditions are much worse.

Operating Benefits Obtainable Through Power-Factor Correction

There are operating benefits to be obtained through power-factor correction, such as:

1. The voltage regulation of the system will be greatly improved. Low power factor reduces the voltage not only because of its influence on the generators, but also by reason of the voltage drop in the transmission and distribution system. Of two equal loads supplied over a line, the one with the lowest power factor will cause the greatest voltage drop.

2. Increases production and insures a more uniform product. Because a variation of voltage means a fluctuation in motor speed that in some cases is sufficient to cause a distinct falling off in shop production, while in other cases the variation in speed causes a varying driving effort that influences the uniformity of machine products.

3. Usually, it is considered that if the voltage drop between the source of supply and the motor is 3 per cent, the energy loss is also 3 per cent. The fact is, however, that the energy loss is inversely as the square of the power factor, so that if the voltage drop is 3 per cent at unity power factor, then the percentage energy loss at different power factors will be:

For an 80 per cent power factor, $\frac{3}{0.8^2} = \frac{3}{0.64} =$ *4.7 per cent.*

For a 60 per cent power factor, $\frac{3}{0.6^2} = \frac{3}{0.36} =$ *8.33 per cent.*

4. Increased investment for larger capacity generators, lines, transformers, feeders and switching equipment to take care of the wattless current. As the investment cost varies approximately inversely as the power factor, a system suitable for 70 per cent power factor costs about 40 per cent more than one suitable for a power-factor of unity. If a manufacturer generates his own current, then he pays these investment costs himself, and if current is purchased, he pays the interest charges upon these investments.

Some power-factor improvement can be obtained by a rearrangement of motors with a view to applying every motor to such a service that it will always be as nearly loaded as conditions will permit. However, plant loading may vary from month to month, owing to changed trade conditions so that a distribution of motors which gives fairly good results in times of prosperity may suddenly become entirely unsatisfactory owing to slack conditions or to a shifting of the load from one department of the plant to another. Thus a plant operating at 75 to 80 per cent power factor as a result of considerable expense in remotoring, may suddenly be found to have its power factor drop to 50 or 60 per cent.

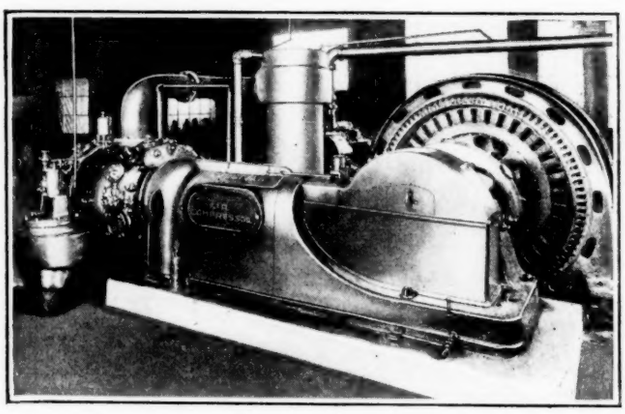


Fig. 1—Synchronous motor directly connected to air compressor

Remotoring, therefore, cannot always be relied upon as a satisfactory solution for low power-factor correction and other means may have to be used. The follow-

ing methods are available: Condensers, static or synchronous; synchronous motors; Fynn-Weichsel (induction-synchronous) motors.

Whatever means are used they may be installed in two different manners:

1. The devices may consist of relatively large units concentrated in one part of the plant, or,

2. They may be distributed over the plant and each be of relatively small capacity.

A static condenser consists of a number of metal plates separated by thin layers of insulation, the whole inclosed in a metal case to protect it from damage. The charging current of a static condenser leads the voltage by practically 90 deg. and replaces an equal amount of lagging current from the induction motors on the system.

Synchronous condensers are synchronous motors operated without mechanical load and with a high direct-current field excitation.

Calculating Size of Condenser

In explaining the method of calculating the size of a synchronous or a static condenser to correct power factor, assume a connected motor load of 100 kw. at 50 per cent power factor. Further assume that it is desired to find the size of the condenser to obtain 80 per cent power-factor.

$$Kilovolt\text{-}amperes = \frac{kilowatts}{power\text{-}factor} = \frac{100}{0.50} = 200$$

$$Reactive\ kilovolt\text{-}amperes = \sqrt{(kilovolt\text{-}amperes)^2 - (kilowatts)^2}$$

$$= \sqrt{200^2 - 100^2} = 173$$

At 80 per cent power factor the line kilovolt-amperes will equal $\frac{100}{0.80} = 125$ and the reactive kilovolt-amperes will equal $\sqrt{125^2 - 100^2} = 75$

Therefore to obtain a power factor of 80 per cent it is necessary to provide 173 — 75 = 98 corrective kva., which is the size of the condenser required. Selection must, of course, be made from standard sizes, the nearest being either 85 kva. or 110 kva.

If an 85-kva. condenser is used, then the power factor will be 75 per cent, while if a 110-kva. condenser is used the power factor will be 84 per cent.

It should be noted that the foregoing method is not strictly accurate, since condenser losses are not considered. However, these losses are a small percentage of the total power and may be neglected in this calculation.

The use of synchronous condensers is limited to what may be termed group correction; that is, a relatively large unit is generally placed in one part of the plant and the correction applied to the load of the entire plant, or the plant, if large, may have one or two such units placed at strategic points. Synchronous condensers like synchronous motors take a leading current which decreases with increasing voltage, so that this type of correction has a beneficial effect upon the stabilization of line voltage. In this respect synchronous machines provide an advantageous method of obtaining power-factor correction, decrease of line losses and a stabilization of the line voltage. The greatest objection to synchronous condensers lies in the necessity of a separate source of current for field excitation.

The operating expense of synchronous condensers is comparatively large, as they require an appreciable amount of energy to run and their first cost is considerably higher than the first cost of other means for correcting power factor.

Static condensers may be used on individual motors, or they may be used to correct the power factor of an installation as a whole. If static condensers are operated in a circuit where high harmonics may exist in the voltage wave of the distribution system, there is danger of heavy surges between the condenser and the circuit which may result in serious damage as well as undesirable fluctuations of line voltage. This means that there must be sufficient reactance in a circuit to dampen out the higher harmonics if the condenser is to be used.

Another characteristic of static condensers causes them to draw a greater leading current as the voltage increases, so that if the voltage of a circuit to which condensers are connected rises, the condensers will tend to increase the voltage still further. On the other hand, synchronous motors or synchronous condensers, when operated at a voltage greater than normal, draw less leading current from the lines and tend to bring the voltage back to its normal value.

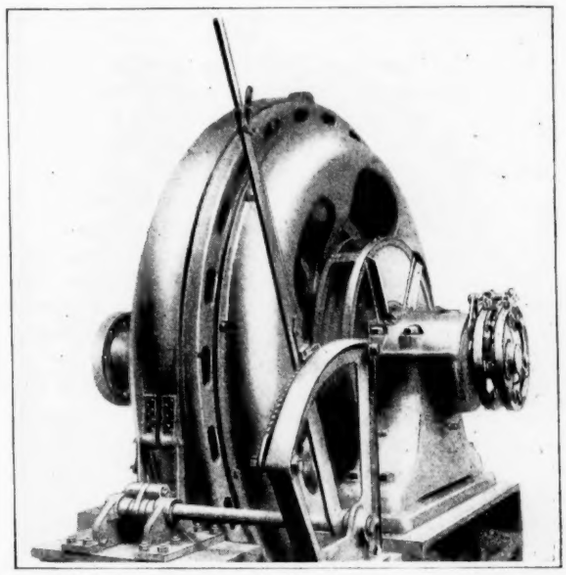


Fig. 2—Large synchronous motor that has a pull-in torque equal to its pull-out torque

It appears, therefore, that the characteristics of static condensers make them more suitable for use with individual motors than for group correction. However, there are many installations of static condensers for group correction, and if they are so installed the following rules should be observed, according to P. T. Vanderwaart, electrical engineer, New Jersey Zinc Co., Palmerton, Pa.:

A. The condenser should not be operated with more than 10 per cent of the units out at one time. This is because there must be a definite ratio between the capacity and the reactance to prevent a resonant condition with resulting surges between the condenser and the power system.

B. The condenser should have a series reactance properly designed to prevent oscillation and surges between the condenser and the power system.

C. No condenser should be reconnected to the line until it is known to be discharged. If not discharged, the condenser voltage and the system voltage are quite

likely to be out of phase and a disturbance will follow the closing of the switch.

D. All condenser units should be regularly tested to determine whether the unit is shorted or open.

E. If there is a high variation in voltage between day and night, arrangements must be made for switching off the condenser when not required. A static condenser will safely operate at more than 10 per cent above normal voltage.

A synchronous motor is excited by direct current and can be operated so as to require no magnetizing current from the line, in which case its power factor is unity, or it can be operated with an over-excited field, in which case its power factor is leading. Installations using induction and synchronous motors together may be operated at a high power factor. Synchronous motors have for many years been used for power-factor correction, but while effective in this particular respect, the relation between their starting characteristics and their pull-in power has limited their general application. Recent developments have to a large extent overcome the limitations. There is now available a general-purpose synchronous motor that has a starting torque and a pull-in torque of over 100 per cent.

Recently, a super-synchronous motor, Fig. 2, has been introduced in large horsepowers. In this motor the stator is carried on a set of bearings so that it can revolve with the rotor. A large brake controls the motion of the stator, and the rotor is coupled directly to the load without a clutch. To start the motor, the brake is loosened so that the stator can revolve, and as the current is applied, the stator revolves backward because the motor load holds the rotor stationary. When the stator reaches synchronous speed, the brake is tightened and the rotor picks up speed as the stator slows down. As long as synchronous speed is maintained between the stator and the rotor, the torque developed is equal to the pull-out torque of the motor.

If the tightening of the brake is done too rapidly,

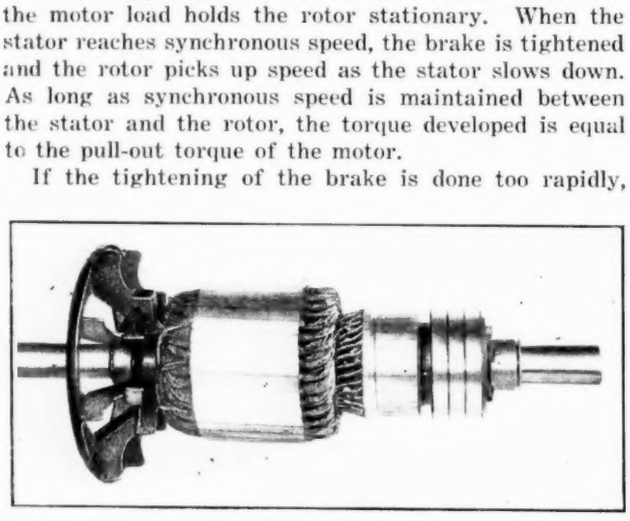


Fig. 3—Rotor of self-excited induction-synchronous motor

In the smaller sizes the commutator and slip rings are on the same end of the rotor as in the figure. In the large sizes, which include 200 hp., the slip rings are placed on the opposite end of the rotor from the commutator

the machine is pulled out of step. In other words, the operator must be skilled so that he will never tighten the brake to exceed the maximum torque of the motor.

Another new type synchronous motor to operate at unity power factor has just been developed in sizes from 60 to 600 hp. This type has a high starting torque and low starting current and consists of a conventional synchronous motor combined with a magnetic clutch in a single unit. Its main advantage is the same as that of the super-synchronous motor already described, namely, starting torque. The machine is brought up to synchronous speed before the clutch is magnetized, so that it can start a load of value equal to the pull-out torque of the motor. This motor should be compared with a standard synchronous motor with separate magnetic clutch. Its advantage over such an arrangement is a saving in floor space.

As previously mentioned, the ordinary synchronous motor is not a general-purpose motor and the demand for a motor that would operate at unity power factor

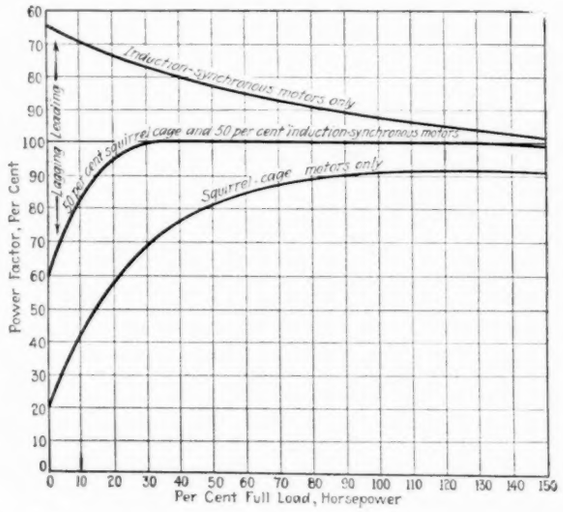


Fig. 4—Power-factor curves of 15-hp. 4-pole self-excited induction-synchronous motors and 15-hp. 4-pole squirrel-cage motors

and have starting and overload characteristics equal to the slip-ring induction motor, resulted in the development of the Fynn-Weichsel induction-synchronous motor. The rotor of such a motor is shown in Fig. 3. This motor is self-excited and operates with unity or leading power factor according to the setting of its brushes. It has a constant speed, starting as a slip-ring induction motor, pulling into synchronous in from 7 to 15 sec., and operates up to 160 per cent load at synchronous speed, and operates from 160 per cent up to 300 per cent load as an induction motor when the pull-in torque is reached. If the load is increased above 160 per cent full-load value and the motor pulls out of synchronism, it pulls into step again as soon as the load is reduced below 160 per cent full-load rating. This motor then has the desirable characteristics of the slip-ring induction motor as well as those of the synchronous motor. The motor also has the advantage that it tends to correct fluctuating voltages.

The curve, Fig. 4, shows the power factor that may be anticipated from this type of motor and squirrel-cage induction motors operating together at loads varying from 0 to 1½ times full load. These curves have been made on the assumption that all motors are 15 hp. 4-pole machines. If the installation consists of different sizes of machines, the curves will change, but the curves in the diagram may be considered as representative of the conditions that may be expected. With 50 per cent squirrel-cage motors and 50 per cent induction-synchronous motors, the power factor is about 100 per cent, from 25 per cent to 150 per cent full load.

Economical Operation *in* Refrigerating Plants*

By O. A. ANDERSON
Engineer, Motive Power Department, Armour & Co.

BY PROPER adjustment of packing house vats, steam can be used at low pressure. Armour & Co. takes advantage of this and by first expanding the steam in the ammonia compressor engines obtains refrigeration at low cost.

IN AN institution as large as Armour & Co. there are in operation all types and sizes of compressor and absorption refrigerating equipment to meet the different requirements, although the absorption installations are comparatively few in number and have been made to meet freezer requirements where there has been an abundance of exhaust steam for the generators and plenty of cold water at low cost. In the slaughtering plants the compression system is used and as a rule engines drive the compressors, but whether to operate condensing or non-condensing is a question for serious consideration.

It will be found that the most economical arrangement is to utilize the exhaust steam in process work where heat rather than motive power is required, except where all water from the steam condensers can be stored conveniently and used without much heat loss. Fundamentally, the approach to a perfect heat balance is the ideal and there is no reason why refrigeration and electric power cannot be developed as a byproduct in the packing house.

Owing to the large requirements for heat in the process work and for hot water, a wonderful opportunity presents itself to develop the necessary refrigeration and electric power from the steam before it is used in the departments. This may mean higher exhaust steam pressures than have been considered heretofore and ultimately may mean some increase in boiler pressures. However, it has been my experience that an increase of agitation of product to be heated and an increase of heating surface have made the use of exhaust steam possible where live steam at higher pressures formerly was used.

High Suction Pressures

Another factor improving economy is to work under the highest obtainable suction pressure to the compressor, thereby increasing the capacity of the machine and reducing the cost per unit of refrigeration developed. Owing to the gradual growth of the packing houses over a long period of years, there has come a time in the history of each plant, when it has been necessary to replace older and inadequate suction lines rather than to add refrigerating machines to correct for pressure drop.

It has been our experience that under unusual conditions operating engineers will maintain unnecessarily more machines in operation than required, allowing the suction pressures to get too low. The engineer rather has cut down on the expansion valves, resulting in superheating of the gas, over-expansion and waste of energy in the power house. If a large plant has been designed properly and operates satisfactorily at a given back pressure, the machines should either be slowed down, if steam driven, or one or two machines shut down, until back-pressure conditions require starting again. This is exactly the manner of operating certain automatic plants. Brine spray systems afford a splendid opportunity for operating at high back pressures, as they permit the use of higher brine temperatures and a lesser temperature difference between the room and the cooling medium.

Wet Versus Dry Compression

Tests conducted at the Eastman Kodak plant a good many years ago indicated that it was more economical to operate with the suction gas rather than the discharge gas, dry and saturated. About five years ago I presented a paper recommending that compressors be operated with slight liquor injection into the suction where dry and saturated suction gas was returning to the compressor. The thought was to overcome in part the superheating and expansion of the suction gas as it came in contact with the hot cylinder walls, when drawn into the cylinder.

Mathematically, it can be shown that a given amount of liquor can be allowed to evaporate in a cylinder of superheated ammonia, and permit an added quantity of suction gas to be drawn in. This can be explained by the fact that the cylinder filled with gas in a saturated condition will hold more pounds of ammonia than when filled with gas carrying considerable superheat. Then inasmuch as the power required in handling the gas is measured by the volume rather than the weight of the gas, except so far as the curve of compression is concerned, there will be a saving in operating with a more nearly saturated gas charge to the compressor.

Analyses made of the losses in refrigerating machines by Messrs. Denton and Jacobus show that even with the use of water jackets on ammonia compressors, the total loss due to radiation and water jackets is only 30 per cent of the heat given up by the cylinder walls directly to the ammonia gas in the cylinders. These tests showed that the loss resulting from superheating of the gas by the cylinder wall ranged from 13.5 to 22.7 per cent, according to the difference in temperatures corresponding to the discharge and suction pressures with dry compression. The values of this loss have been plotted in Fig. 1.

Conditions controlling this loss apparently are temperatures corresponding to the suction and discharge pressures. Inasmuch as no economical control can be

*Abstract of paper read before the American Society of Refrigerating Engineers, Chicago, June 3, 1926.

made of the suction gases beyond a dry and saturated return, the only place for correction is regulation of the discharge temperatures, thereby controlling the volume handled. This is a field that has been entered by the manufacturers of multi-stage compressors. The saving is effected by eliminating some of the superheat through a reduction in the compression ratio of a cylinder.

One of our plants made a campaign toward operations along these lines and the next year reported a big saving in ammonia consumption, reduced attention to stuffing boxes and rods, and refrigerating duty performed with a reducing tonnage.

A number of our plants are using liquor injection to advantage, owing to the fact that they are returning to the compressors dry and saturated gas. This is a more economical arrangement than returning liquor to the machines in slugs and operating with a cold discharge.

There is a point of operation between dry and wet compression that is more economical than even dry compression. We have found that with condenser pressures averaging 175 to 185 lb., the discharge temperature of the gas should be about 200 deg. F. This has been our guide in controlling the liquor to the machine.

Selecting Ammonia Condensers

In selecting the proper type of ammonia condenser, it is important to consider the operations not alone for the extreme hot-weather conditions, but during the rest of the year as well. When cold water is available,

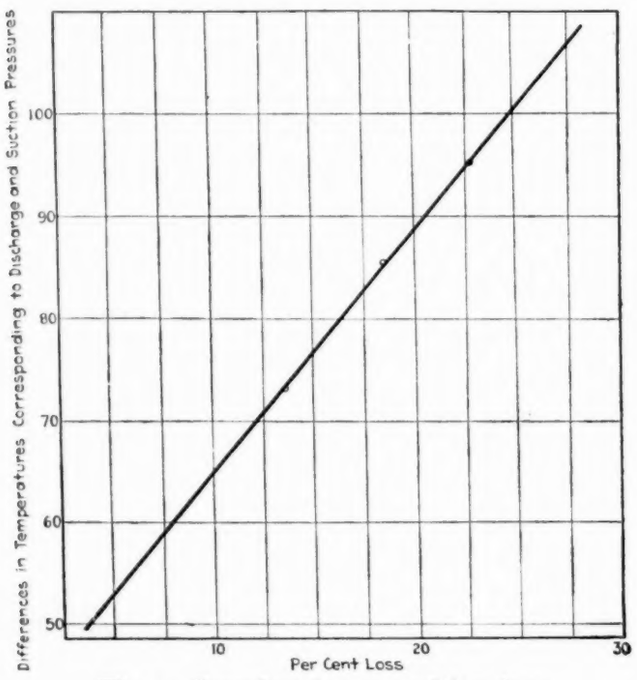


Fig. 1—Superheat losses resulting from heat of compression

shell condensers are efficient. Being located at the ground level, pumping costs are reduced. Such an installation was completed recently in Milwaukee, where 52-deg. well water was available, and the condenser was placed in the engine room, so that the pumping head for the water was less than 25 lb. Formerly, with atmospheric condensers on the roof of a four-story building, the head pressure was 135 lb. Changing to the shell-type condenser reduced it to 115 lb.

On the other hand, careful analysis must be made to determine whether shell condensers will pay during the entire year where cooling-tower water is used. There are many cases where a reduced volume of water can be pumped in the winter season, and furthermore, the benefit obtained from the atmosphere as a cooling medium is lost when condensers are placed in the engine

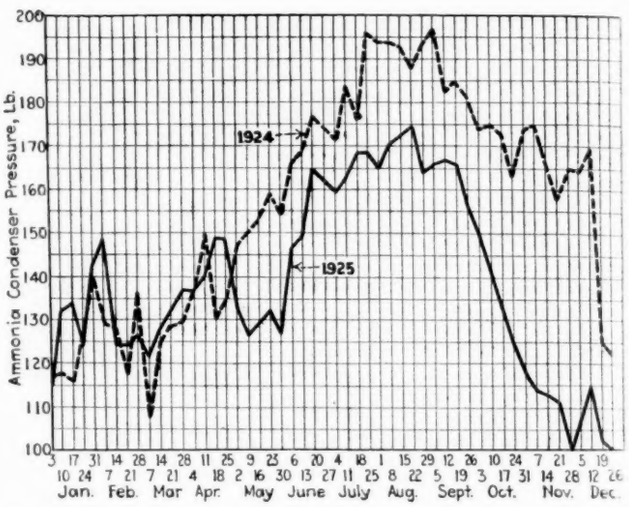


Fig. 2—Atmospheric condenser pressures reduced by improving air circulation

room not equipped with forced-air circulation, requiring additional power.

Investigation of our atmospheric condenser installations has shown that air circulation and proper venting of the condenser loft is important. In a refrigerating plant in New York City I found that the ammonia condensers were placed so that air circulation was impaired. A wall was on one side, a large penthouse on another side and a part wall extended on the third side. Fortunately, the windward side was free and open, but inasmuch as the condensers were so well inclosed on the other sides and a double, staggered louvered roof extended over the top, the vapors from the condenser did not carry away as they should. The only recourse was to remove one of the staggered layers of roof louvers, and if this did not help it had been decided to remove all the roof louvers. On the removal of one layer a big improvement in condenser pressures resulted, as shown in Fig. 2, which gives average ammonia condenser pressures for the year before and after the change, which was in the first part of February, 1925. It will be noticed that a sudden drop in pressure occurred. Furthermore, more tons of refrigeration were produced in 1925 than in 1924. An appreciable saving in coal consumption resulted and reflected itself directly in the cost statement for the year.

On one of the warmest days of the summer of 1924 I made some tests in the Chicago plant to determine the air circulation and effectiveness of the water over the atmospheric condensers, which were constructed 24 pipes high. These records are shown in the accompanying table. It will be noticed that in the case of the first test, where the air circulation was poor, practically no cooling of the water itself took place. On

the second test cooling of the water actually lowered the water temperature below the maximum temperature. The third test was made on a system independent of the other two in which the air circulation was good. It is evident that the stands exposed to good circulation received substantial benefit from water evaporation in addition to the cooling by conduction. These tests also brought out the fact that the first six pipes handled the major part of the load, and further, that beyond the twelfth stand practically no work takes place.

Kinks in the Distribution System

The most perfect ammonia evaporating system provides the possibility of operating with a suction pressure corresponding to a minimum temperature difference between the ammonia and the medium to be cooled,

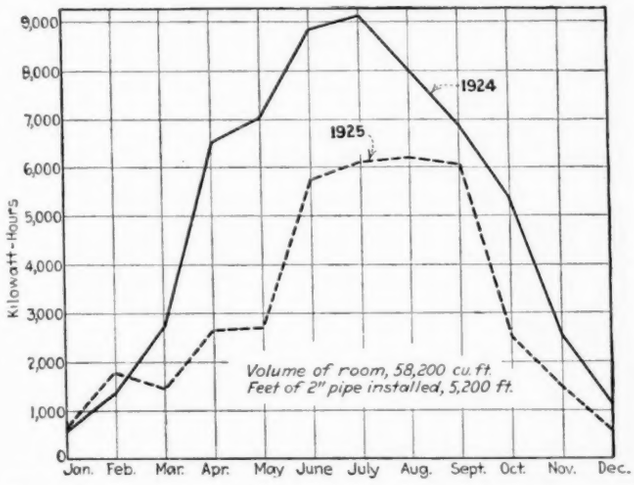


Fig. 3—Comparative power requirements before and after installing XL no-freeze control valve system

also a minimum pressure difference between the ammonia in the cooling equipment and the suction pressure at the machine. Pressure drops on the expansion side of an ammonia system are a total loss and continuously contribute to increased operating expense. The ideal ammonia evaporator is the shell-type brine cooler, barring possible mechanical weakness or hazards with this type of cooler, owing to the difficulty of rigid inspection and possible freeze-ups. The nearest approach to this ammonia evaporator is short expansion coils operated as a flooded system.

To operate under these conditions requires an adequate ammonia charge. It is surprising to find the great number of ills in the average refrigeration plant caused by lack of ammonia. An adequate charge of ammonia will eliminate unnecessary hours of operation of the ammonia compressor. Operating with a truly flooded system and the suction gas removed from the top of the coils, also will permit the return of dry and saturated gas to the compressor.

In the operation of automatic refrigerating plants, there must be proper protection against carrying liquor back to the compressor. Furthermore, owing to the rather long time lapse between inspections, the expansion valves must be adjusted to meet the requirements throughout these periods. As a safeguard, sufficient extra expansion piping has been provided to serve as a trap or safety coil to prevent liquor passing to the compressor. This has resulted in superheating and over-expansion of the suction gas, causing a proportionately greater number of hours of gas pumping and finally a higher electric bill.

In February of 1925 we installed in one of our branch houses an XL valve designed to overcome just such a condition. This valve operates thermostatically on the liquor feed to close it when the gas leaves in a wet condition. Fig. 3 shows the power consumption for the years 1924 and 1925. With the special valve installed during the latter year, it will be seen that a substantial reduction in power requirements took place. This improvement was due in part to the installation of a hot-gas defrosting system, permitting operation with clean expansion coils, as compared with coils heavily covered with ice.

It should not be inferred that the valve will show equal results in all cases, owing to the comparative difference in previous operating conditions. However, it may be used to advantage in the case of automatic plants, shell-type brine coolers, lard rolls, etc., from a safety viewpoint, independent of the saving possibilities. It is interesting to find that the frost line consistently stops at the same point for a given adjustment of the hand valve.

Reducing Non-Condensible Gases

Another item contributing to the cost of operation of refrigerating plants is non-condensible gases. Although a separator designed to separate these gases from the ammonia is available, it is desirable to prevent the formation of these gases, at least in part. During the last few years I have made a concentrated study of a few plants that have suffered more seriously from non-condensible gases. After having read the bulletin by the late Mr. McKelvy, of the Bureau of Standards, on the causes and remedies for non-condensible gases in absorption plants, I was convinced that the same ills prevailed in the compression plant, namely, either air is taken in at rods or piping connections on pump-downs, or there is formation of hydrogen gas from corrosion of the metal in the ammonia system, owing to impurities in the ammonia, particularly the presence of water. From the experience of all of our larger plants I knew that considerable water was removed daily from the system through purifiers and therefore there was no reason why corrosion should not be active in the direct-expansion system, as well as the absorption system, though perhaps to a lesser degree. The water finds its entrance possibly through the air which is drawn in and chilled.

The bulletin indicated the entire elimination of hydrogen gas by using a small percentage of sodium or ammonia dichromate, so I tried charging the same chemical into the ammonia system of one of the compression plants. It was found convenient to charge the chemical into a pot strainer in a bypass connection to the main liquid line feeding the entire refrigerating system. Until this time it had been necessary to purge the condensers twice a week to maintain proper head pressures. Furthermore, there always had been an excess of condenser pressure to the extent of 25 to 40 lb. over that corresponding to the temperature of the ammonia liquid leaving the condensers, as well as an unusually high ammonia consumption caused by the heavy purging.

The sodium dichromate went into solution after several days, and the head pressures ceased climbing and no added ammonia charging was necessary. Careful

records were kept and the excess condenser pressures were reduced to from 0 to 9 lb. and have been maintained within this range up to the present time. The ammonia consumption was greatly reduced. Sodium dichromate was added until the system would take no more into solution. Later, an analysis of siftings that had accumulated in the strainer showed an iron content of 21.36 per cent. This indicated corrosion action

WATER TEMPERATURE AT VARIOUS HEIGHTS ON 24-PIPE HIGH AMMONIA CONDENSERS

Time: 3:10 p.m.		No. 1	
Water Temp., Deg. F		Spread	
Above top coil	69		
Leaving 6th coil from top	88	19	
Leaving 12th coil from top	92	4	Poor air circulation
Leaving 18th coil from top	92	0	Air temp. 92 deg. F.
Leaving bottom coil	93	1	
Total		24	
Time: 3:30 p.m.		No. 2	
Water Temp., Deg. F.		Spread	
Above top coil	68		
Leaving 6th coil from top	78	10	
Leaving 12th coil from top	80	2	Better air circulation
Leaving 18th coil from top	81	1	Air temp. 85 deg. F.
Leaving bottom coil	80	—1	
Total		12	
Time: 3:40 p.m.		No. 3	
Water temp., Deg. F.		Spread	
Above top coil	80		
Leaving 6th coil from top	90	10	
Leaving 12th coil from top	94	4	Good circulation
Leaving 18th coil from top	92	—2	Outside temp.
Leaving bottom coil	89	—3	85 deg. F.
Total		9	

on the iron in the system. The finding of substantial pit marks on the inside of certain pipe coils that had been in service in the Chicago plant for over twenty years gave further evidence of corrosion. Since the first test with sodium dichromate its use has been extended to practically all the larger plants with a marked degree of success.

Hydraulic-Turbine Governor Pressure Fluids

By M. B. Thurston

There are several points about governor fluids that should be given careful consideration, particularly if trouble is being experienced. Centrifugal pumps have been used, in some cases, to pump oil for the governor system, and generally they have given so much trouble in the churning and breaking down of the oil that they have been taken out and some type of rotary piston or plunger pump installed. The many vanes of the centrifugal pump, cutting into the oil 6,000 to 20,000 times per minute, like an egg beater, are blamed for oil troubles in this class of work. The slower the pump can be run, the better the oil will hold up and the longer it will render good service.

Some oil-pressure systems have had to be operated under excessive pressure, and by that are meant pressures between 250 and 300 lb. per sq.in., because too small a governor was originally installed. When it was found that the gates could not be closed under usual pressures, the oil pressure was raised. High pressures and high velocities in the piping are destructive to long oil life. Of later years in new plants 150-lb. oil pressure is being specified for many installations, although pressures of 175 to 200 lb. are being used. A mistake frequently made that shortens oil life is that the oil is allowed to get too hot. When it is found that an oil pump of the gear or screw type heats the oil to 120 or 140 deg. F., one may be sure that this will not help matters any, and either a larger pump that can be run slower should be put in or else the offending pump examined for rubbing or other defects. Gear pumps have been made with too close clearances and too small shafts, so that the deflection under pressure caused rubbing and heating.

What oil appears to be best for the oil pressure governor? My preference is a fairly light oil, of good flash test, strength of film and stability. The reason for this is that all oils will tend to foam where automatic air bleeders are used. A light oil will tend to clear itself of bubbles quickly, while heavier oils will not do so. Where the oil-pressure storage tank is of ample size, this clearing action is greatly helped. Large piping, connecting the governor pump and tank, and from the tank to the servomotor cylinder, keeps down friction losses and also reduces the dead time of the governor, thereby getting the oil into the cylinders more quickly.

I am not so favorably inclined to the various oil substitutes sometimes used instead of all oil. The operating parts, such as the governor cylinder, should be brass lined in such cases and the pistons and their rods should be of brass, not to mention the piping. There is a greater likelihood of settlings and scale forming if iron pipes are used and they may get to the pilot valve and cause trouble by clogging, although a great deal depends on the care and attention given the individual case. An all-oil system does not cost enough more per year to justify the substitute, in my opinion.

Using water substitutes for oil came to my attention about 1908, and it must be admitted that it presents an attractive argument in favor of economy. There are two ways of looking at the idea—first, the small and medium plant, and then the large plant. No one would consider a water substitute for the governor oil in small or medium-sized plants. Water is not a lubricant and its qualities vary greatly in different localities. A treatment that would be good in some localities would not work well in others. There is always the danger of some precipitate, which, if not considered when the governor system is designed, may lead to trouble. Large governors have rather large ports in the regulating valves, and what might go through a large valve might clog a small valve. Pilot valves are made within thousandths of an inch and even some brands of oil will eat away ordinary steel, let alone water mixtures. Many governors now have pilot valves made of heat-treated nickel steel. Of course, pure oil governor systems are not without their troubles.

Will Steam Supplant Hydro in California? "That the present ratio of one-third steam and two-thirds hydro which holds for the installed capacity of California will be radically changed or possibly reversed is the opinion advanced by certain engineers who have been studying closely the power situation in the state," says the *Journal of Electricity*. Deficient water supply, increasing cost of hydro developments, the reaching of the possible maximum efficiency in hydraulic machine design and, most important, the increasing efficiency of steam-power generating equipment are among the reasons to which this change is ascribed.

Oil Engines as a Drive for Pipe-Line Pumps*

A Survey of the Use of Diesel Engines on Pipe Lines—Data Pertaining to Pipe-Line Systems Leading Out of the Mid-Continent Area. A Discussion of Pipe-Line Practice and Comparative Costs

By FRED THILENIUS†

PROBABLY the least-known industry in this country today, considering its size and importance, is the pipe-line transportation of crude oil. It is consequently true that little is known, in general, or even in engineering circles, of the extent to which the Diesel engine has been used in this industry. Pipe lines were among the first to give the Diesel a trial and to adopt it in a large way as a standard form of power. Thousands of these engines have been installed in pumping stations, where a real service is demanded of them, and many large systems have been operating entirely with this form of power for almost a decade with excellent results.

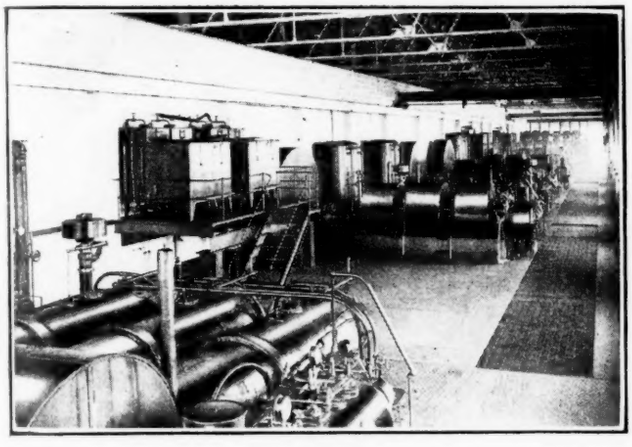


Fig. 1—Prairie Pipe Line Plant with horizontal Diesels equipped with filtering system

Main-line practice consists in laying one line, or parallel lines, of 6-, 8-, 10- or 12-in. pipe across the country from the group of territories to be served to the delivery points, with a pumping station located about every 40 miles. Each station pumps into receiving tanks at the next station, usually of 35,000 to 55,000 bbl. capacity, from which the oil is again picked up and pumped to the next station. The usual pressure maintained on the pumps is 700 lb. per sq.in., and at this pressure a single 8-in. line 40 miles long will carry approximately 20,000 bbl. per day. Pumps for main-line stations are therefore usually of 20,000 bbl. per day capacity for smaller stations where there are but one or two lines, and from 30,000 to 40,000 bbl. per day capacity for the larger stations having multiple discharge lines. Horizontal duplex and triplex single-acting tandem plunger pumps of from 4-in. to 6½-in. bore and from 18-in. to 36-in. stroke are the most commonly used. The engine capacity required for driving the pumps is, roughly, 15 hp. for each 1,000 bbl. per day pump capacity for the 700 lb. per sq.in. pressure maintained.

Gathering-line practice consists simply of locating small stations in convenient places in the oil pools as they are brought in, usually in a low spot somewhat downstream from the pool so that the oil can be brought to the station by gravity, and running discharge lines from these stations to the nearest points on the main line. In this case the size of the line, the distance pumped, and therefore the pressure and power required for different capacities, may be almost anything, depending on the local conditions. The units therefore range in size from a 3x10-in duplex piston pump driven by a 25-hp. engine, to a full-sized main-line pump driven by a 300- or 400-hp. engine.

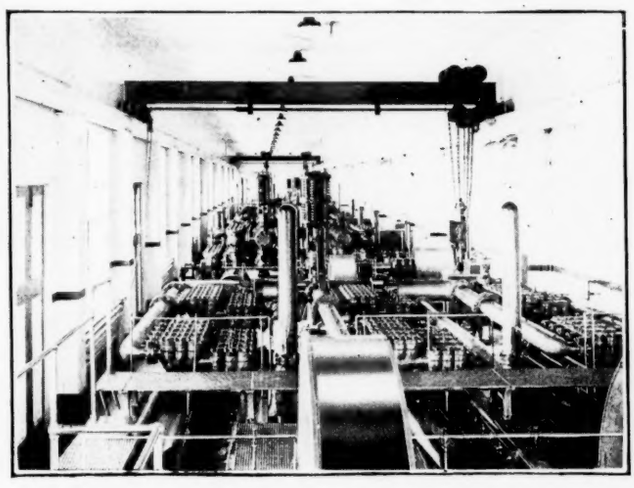


Fig. 2—Pumproom of plant shown in Fig. 1; fire wall separates the engines from the pumps

To complete the description of pipe-line practice it should be mentioned that all stations are operated on a 24-hour basis, by three 8-hour shifts, or "tours" as they are called in pipe-line parlance, and that all stations of a system are in constant communication with each other and with central points through an independent tele-

*Extract of paper read before the Spring Meeting, American Society of Mechanical Engineers, San Francisco, Calif., June 28, 1926.

†Assistant Master Mechanic, Prairie Pipe Line Co.

graph system whereby oil is dispatched by orders much the same as trains are on a railroad.

In 1890 the triple-expansion steam pumping engine made its appearance on pipe lines. Owing to its comparatively complicated mechanisms, it met with much opposition at first, but soon replaced all former equipment. When run with a condenser, this type of engine has a steam consumption of about 15 lb. per hp.-hr. Many of these units are still in use. Where cheap coal is available for burning under boilers or where there are other considerations, such as exhaust steam being required for heating very heavy oil to make it flow through the line, or where very old existing plants have had their cost almost entirely written off by depreciation charges, as is the case on the Eastern lines, such units are likely to remain in use for some time to

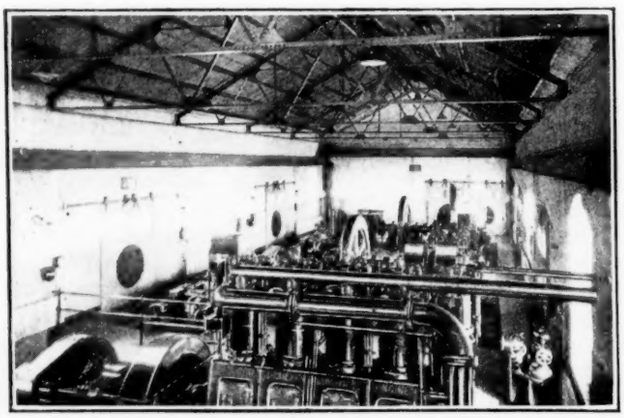


Fig. 3—Sinclair pumping station has both horizontal and vertical engines

come. On the lines leading out of the Mid-Continental field, where oil only is to be considered for fuel, it has been almost completely replaced by the Diesel engine, which has a still better fuel economy and has shown itself amply qualified to meet all pipe-line requirements.

Diesel Engine Saves Oil

Roughly, the steam pumping engine required 1.5 lb. of oil burned under boilers for each hydraulic horsepower developed in the pump, while the Diesel engine consumes but a third of that amount for the same performance. This amounts to a saving of 1 lb. of oil per horsepower-hour, or about 25 bbl. per horsepower-year for the Diesel engine figured on 80 per cent load factor. This is not the whole story, of course, but this saving in fuel amounts to something like a million and a half barrels per year when applied to the total oil-engine equipment in operation for either of the first two companies listed in the table. This is quite an item, and it might be mentioned here that even if other costs connected with Diesel-engine operation nearly offset this saving in fuel, a change to such a type of power would be well warranted from a conservation viewpoint alone.

To the author's knowledge, the first trials of Diesel engines for pump-station use were made in 1913 simultaneously by several of the companies. One such installation was made at Neodesha, Kan., another at Caney, Kan., on the Prairie pipe-line system, and still another at Jenks, Okla., on the Oklahoma pipe-line system. These were of the semi-Diesel, or hot-plate type of engine. In each case several 100-hp. four-cycle horizontal single-cylinder engines coupled to vertical triplex pumps of about 7,000 bbl. per day capacity, were set up to compete directly with existing steam plants on these lines. Owing to overloading of the engines, inexperienced operators, and other factors, much grief was experienced in these first tests. The results showed no great net saving in money. But the trials demonstrated that the oil engine could hold its own in the way of service demanded on pipe lines, and the future possibilities were readily seen.

Other Installations Made

A year later two larger installations consisting of two-cylinder 300-hp. engines, each of the same type, were set up at other points, and at about the same time an entire oil-engined line 200 miles long with four pump stations was built across the State of Missouri. Other installations followed rapidly. In 1916 the full Diesel engine in larger sizes made its appearance on pipe lines, and about a year later all Mid-Continental companies were engaged in extensive programs of converting their steam equipment to Diesel-engine drive. In the meantime many new lines were built, and existing

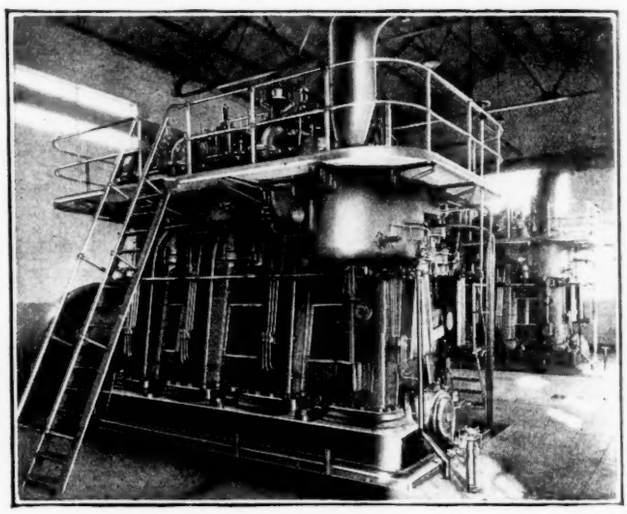


Fig. 4—750-hp. Diesels in one of the newer installations

lines increased, with oil engines as original equipment. The greater part of the Diesel-engine equipment listed in the table was installed between 1917 and 1923.

It is the universal practice to have all main units directly connected to the pumps, usually through herringbone gears of about 1:5 or 1:6 ratio so that the speed of the pump is from 30 to 40 r.p.m. It is also the rule to have a flexible coupling on the pinion shaft between the engine and pump.

Main-line stations are usually in charge of chief engineers, who in some cases report to the mechanical department, but who more often are under the district field superintendent, in which case the mechanical department acts in an advisory capacity. The smaller stations, containing but two units, are usually operated by one engineer on each tour. Stations containing four units usually have a crew of one engineer and one oiler on each tour, and in the largest stations containing six or more large units there is usually an extra oiler on each tour and a daytime clean-up man. In the first two cases the crews make their own minor repairs, and

a district machinist who covers three or four stations usually aids in making major repairs. In the case of the largest stations, especially while they are required to pump full capacity, a crew of one machinist and one or two helpers is constantly maintained at each station to make all repairs.

Since pipe lines for obivous reasons shun towns as much as possible, the stations are as a rule in somewhat out-of-the-way and at times very isolated localities; and, are usually forty miles apart. This means that the power plants are scattered over great distances,

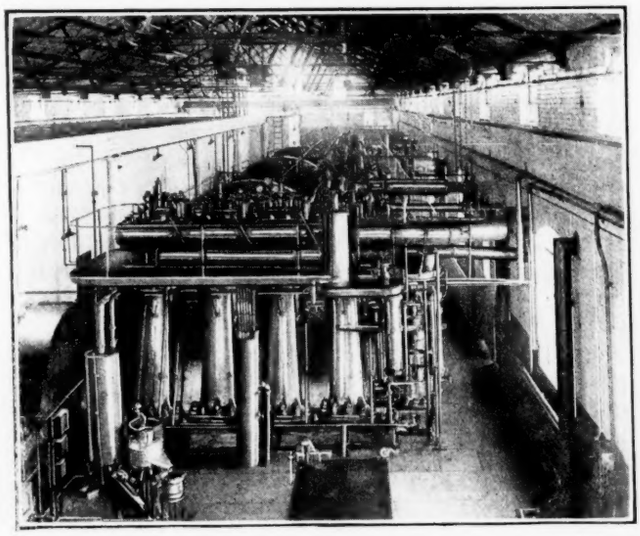


Fig. 5—This plant contains six 500-hp. units; exhaust heat is used to treat the lubricating oil

making intensive supervision rather difficult. Much of the operation therefore depends on the chief engineer, who is usually given a rather free hand.

The first cost of a medium-sized Diesel-engine station of, say, 50,000 to 100,000 bbl. per day capacity is practically the same as that of a modern steam plant of the same capacity with all accessories necessary for good economy, even though a spare unit is included in the case of the Diesel engines. The interest on the investment can therefore also be taken as the same.

From all information at hand, after thirteen years of operation, with the first units installed there is now every indication that the depreciation of the Diesel engine can be assumed to be the same as that of the steam engine itself, and to be less, if anything, than that of the combination of steam engine and boiler equipment.

Dependability is an important item in pipe lines. It was to determine this dependability on 24-hour service that the first trials were made. It has been found that the oil engine needs a little more attention and more frequent adjustments. It cannot be overloaded for any great length of time like the steam engine, and should not be forced to operate when in distress; but this is taken care of by the spare unit which is included in the first cost, so it cannot be held against the Diesel engine. With proper attention and intelligent operation it has been found to be as dependable as the steam engine.

Operation includes mainly labor, lubricating oil and fuel oil. The labor required for a Diesel plant compares very favorably with that for a steam-engine plant of the same capacity. The lubricating oil for the cylinders of a Diesel engine must of course be of a higher quality and therefore of a higher price per gallon than for the steam engine, but the bearing oil in most cases can be the same, and with proper feeding of oil to the cylinders and proper care of the bearing oil in circulation, the total cost per horsepower-hour developed can now be assumed to be almost the same as for the steam engine. This leaves only the fuel consumption and maintenance to be considered.

Maintenance Costs Higher on Diesels

As previously mentioned, the fuel consumption is about one pound less per horsepower-hour for the Diesel than it is for the steam engine. But the maintenance is considerably higher on Diesels, and since all other items are roughly equal and can therefore be cancelled, the whole matter of comparison can be boiled down to balancing the additional maintenance necessary on the Diesel engines against the fuel saved.

Maintenance is therefore the most important factor to keep in mind in the operation of Diesel engines. It can vary considerably for different plants, depending on many things, and can increase to alarming proportions when the best Diesel practice is not strictly adhered to, and the problem has been mainly to learn what constitutes the best practice for this service. The Diesel can receive preference over the steam engine only so long as the maintenance per horsepower-year is less than from $25 to $35, and there is no denying that the maintenance on the earlier installations very nearly approach this figure. It was still extremely high as late as five or six years ago, but it is safe to say that now the general average for all companies is well below $5. There is every incentive to reduce this item still further, for every dollar saved in this direction is money made. Almost all improvements that have been made, or are being made, have been contemplated with this end in view. Some of the most important of these comprise reduction of engine load, improved operating conditions, provision of a spare unit, improved cooling water and lubricating-oil systems, the use of pyrometers or thermometers on exhaust lines and more careful selection of operators. Better engine design has, of course, also affected maintenance.

Reducing Load Saves Maintenance Cost

In the earlier installations it was the rule to load the engines to what was thought to be their full-rated capacities. About five or six years ago it became the general practice to relieve the engines of from one-eighth to one-sixth of their load, and most installations since that time have been made on that basis. It has been found that this reduction in the load on the engine has decreased maintenance considerably.

The rating of a Diesel engine is based on ideal conditions. Any neglect, such as improper lubrication, scale in the jackets, leaky valves, choked spray nozzles, uneven load on the cylinders, or any misadjustment, immediately affects the ability of the engine to carry its load, especially on 24-hour service, a fact that was not given proper consideration. Neglect of the steam engine usually resulted mainly in decreased efficiency of the plant, but neglect of the Diesel engine as a rule means increased maintenance. Some of the neglect was due to carrying over, to some extent, steam-engine principles in operation.

To insure periodic attention to all parts of the engine,

one company has now in force a system of daily log sheets covering all important parts of the engine. Repairs made, measurements taken, parts cleaned and conditions found during inspection of the engines are noted for each engine at each station. A monthly summary of all daily sheets is sent to the main office, where a check can be made on the care that each unit has received during the month. Another company has in force a periodic checking of crankshaft, etc., by machinists, who send in the information on specially prepared blanks. In addition the engineers in charge have learned that periodic inspection and more thorough daily attention save them much work on repairs.

It was not considered necessary at first to have a spare unit, and engines were often required to run while in distress. It has now become the practice to provide a spare unit in all stations. This has helped maintenance considerably in allowing an engine to be shut down whenever necessary before any great damage has been done.

It is a fact, of course, that the Diesel-engine plant requires much less water to operate on than a boiler plant of the same size, and that bad water does not entail the trouble, expense or danger when used for cooling water in Diesel-engine jackets that it does when used in boilers. There was consequently very little thought given to water problems at first. Cooling-water systems have been mainly of the gravity, surface-cooling type, and until recently raw water and earthen reservoirs were the rule. The result was an accumulation of mud and scale in the jackets, which necessitated frequent washing out of the mud and periodic reduction of the scale with acid. If the cleaning of the engine was neglected, maintenance increased, and even if the cleaning of the jackets was done religiously, the engine was affected to a greater or less degree between cleanings. It is now the almost universal practice to provide concrete reservoirs at all main-line stations, and several companies are using some sort of water treatment to remove the scale-forming elements before the water is put into the system. To treat the water chemically is of course an operating expense, but the lack of such treatment usually results in a maintenance charge in the nature of broken cylinder heads, seized pistons, or burnt-out piston-pin bearings. Furthermore, the expense of treatment is a good deal less than the cost of the acid and the labor required for periodic cleaning.

A considerable reduction in maintenance has been effected by improved lubricating oil systems. It was at first generally believed that the old steam-engine filter, usually recommended and furnished by the engine builders, would be sufficient to keep the bearing oil in good condition, and that the fine particles of carbon collected by the oil were, if anything, a help to lubrication. The filter was a strainer at its best, which allowed the oil to become more and more saturated with carbon and did not remove the water present. This usually resulted in the feeds becoming undependable and in excess oil being fed to all points for safety's sake. It also resulted in excessive bearing wear, for it has been found that the carbon particles made a rather good grinding compound. When the oil became extremely dirty, it was the practice to treat a batch of 50 gal. or so at a time in chemical reclaimers and return it to the system, but in most cases proper heat for the reclaimer could not be obtained. The later practice has been to keep the oil in a much cleaner condition at all times. This has been accomplished in several different ways.

On one line a centrifugal separator has been installed for each engine, which cleans up the oil as it leaves the engine and before it is returned to the overhead tank for recirculation. On another line an elaborate lubricating system has been developed, where the oil from the engines is settled and partly cleaned as it flows through heaters and remodeled filters before it is returned to the overhead tank, and where it is more thoroughly cleaned and dehydrated by a centrifugal purifier which is constantly working on the oil in the overhead tank. All the oil in the system, in this case, is kept hot, and a cooler is provided for cooling the stream of oil before it goes to the engines.

How Clean Oil Has Been Obtained

On other lines clean oil has been obtained, either by having a much larger quantity of oil in the system than formerly and providing large settlement compartments which give the oil a chance to rest and settle on its trip around, but which necessitate periodic cleaning of the whole system, or by having double overhead tanks so that all the oil in one tank can be thoroughly cleaned in chemical reclaimers or centrifugal purifiers while the station is operating on the second tank. The crosshead type of vertical engine with an arrangement for catching the drip oil from the pistons and keeping it out of the crankcase has aided considerably in keeping the system in a much cleaner condition. Clean oil has resulted in greatly reduced bearing wear, which not only affects maintenance but reduces operating cost.

To enable the operator to check each engine hourly and keep the load balanced on all cylinders, several of the companies have adopted the use of pyrometers or special mercury thermometers for indicating the temperature of the exhaust coming from each cylinder.

DIESEL ENGINES IN THE MAIN-LINE STATIONS OF THE MID-CONTINENTAL COMPANIES

Name of Pipe-line Company	Approx. Miles of Line in Operation	Number of Oil-Engine-Driven Main-line Stations	Types of Engines — Horizontal—4 Cycle — 1 Cyl. No. Hp.	2-Cyl. No. Hp.	3-Cyl. No. Hp.	Vertical—4 Cycle — 3-Cyl. No. Hp.	4-Cyl. No. Hp.	6-Cyl. No. Hp.	Vertical—2 Cycle — 3-Cyl. No. Hp.	4-Cyl. No. Hp.	Total Main-line Oil-engine Equipment No.	Hp.	Main-Line Auxil. Engines No.	Hp.	Gathering Line Station Oil-Engine Equipment No. Sta's	No. Eng's	Total Hp.
				9 150	26 300	9 500	16 300	10 665	3 600			1 750							
					8 360	15 600		12 500											
Prairie	11,400	33						8 400					121	50,560	33	1,020	87	138	8,700
								2 550											
								2 365											
					6 300		7 300	17 500	4 600	6 750	6 750								
					40 250			6 520			10 440								
Sinclair	6,000	49			6 200			12 400					128	52,010	49	1,800	73	106	7,250
								6 365											
								10 250											
Oklahoma	1,400	15			29 300	2 500		6 400	1 600				38	12,700	15	600	16	21	1,700
Standard of La.	2,000	11	43 100		36 300		5 300						98	18,700					
			14 150																
Gulf	3,300	19	110 100		3 200								133	14,600	19	475			
			20 150																
Ozark	1,000	10				40 250							40	10,000					
Magnolia	2,900	27	100 100		17 360			2 150					127	17,480	27	525	48	73	3,650
			4 140		4 200														

Hard Water

THE operating engineer does not choose his problems, as does the professor; they are forced upon him. They are mechanical, electrical, managerial and —to keep from enjoying life too much—chemical as well. It is one of the ironies of fate that the operating man, who more often than not has never had a formal course in chemistry, is faced with chemical problems to which he must find practical solutions. He must burn fuel and he ought to burn it efficiently. Enter combustion, a complex chemical process! Then comes feed water, generally "hard" in fact and harder to understand. Even the chemists, specialists in the field of feed-water treatment, do not understand all about it. They are not certain what happens to substances in solution at boiler pressures and temperatures.

But the chemical engineer has a message for the operator. He can give him a lot of practical pointers on the safest and most economical methods of preventing scale, avoiding bagged boiler tubes and mitigating the evils of foaming and priming. Feed treatment is one of those complex specialties in which the average all-around engineer can profit by the advice of an unbiased expert. Sheppard T. Powell, author of the series of articles on feed water now running in *Power*, is the first to cover the whole subject comprehensively in the light of present-day knowledge. His conclusions are given in a form directly applicable to boiler-room operation.

Boiler-Plate Embrittlement

A DECADE or more ago what seemed to be a new type of boiler failure began to appear with startling frequency. Drums that on superficial examination appeared sound showed serious cracks hidden beneath butt straps and rivet heads. Evidently, the metal at the time of failure was bad. Either the material was bad to begin with, or it became bad subsequently, during fabrication or during operation.

If the metal was initially bad, the explanation is complete and the remedy is obvious. Better steel must be used. This hypothesis lays the entire matter at the door of the boiler manufacturer.

If, on the other hand, initially good metal became bad, the cause must be sought. Is the deterioration the result of mistreatment of the metal in the boiler shop, or in service? It is certainly possible to cold work metal in fabrication so as to produce serious internal stresses which will lead to cracking. It also seems possible that there are certain operating conditions that will induce embrittlement.

One of the first intensive studies indicated that embrittlement of the type studied never occurred save in the presence of water carrying certain proportions of dissolved salts together with caustic soda. It has since been found that even such waters produce embrittlement only in overstressed metal.

And so there have arisen two schools of belief as to the cause of this dangerous condition. One holds that internal stress is the whole story, the other that an excessive proportion of caustic soda and stress beyond the yield point are both necessary. The first school maintain that water conditions have no influence except perhaps as a secondary accelerating effect. They point out that overstressed metal has no place in a well-made boiler. The second school admit the undesirability of high localized stress, but hold that such conditions are unavoidable in riveted drum construction. Stress is always present, they say, and leads to embrittlement only with certain water conditions.

Are there not several kinds of causes for embrittlement? May not both schools be right? Are all embrittlement cracks from the same cause? The boiler user is intensely interested in the answers to such questions.

But the boiler user cannot be content to sit idly awaiting the conclusions of what is to him in a measure an academic question. After all, he cares little by what name his trouble is called. His demand is for some remedy that will enable him to operate safely. Whether the remedy is scientifically rational or purely empirical is interesting, but not vital to him. Even a "hunch" is good enough for him if it works. True, there may be a cheaper and better way to be developed through further research, and this the operator wants, but he dare not wait for it. He must do something now.

What shall he do? Two factors are involved—stress and water conditions. Perhaps the elimination of either alone will cure the disease, but since both are under suspicion, why not do all that can be done to eliminate both? Severe internal stress is admittedly bad on all counts. Let every effort be made to eliminate it by insisting on first-rate material and the best possible shop practice. Certain materials in solution in the feed water seem also, in some instances at least, to be a contributing cause. Let care be taken in adding such things to the water or in neutralizing them if they are already present.

Binary Vapor Cycles

LIMITS of the various possible cycles when steam is used, have been analyzed by engineers and are fairly well recognized. In fact, the definite trend toward higher temperatures and pressures in modern steam plants is largely due to the improved efficiency that such increases promise in the analyses of the various steam cycles.

The highest efficiency that may be secured with a perfect gas is that given by the Carnot cycle and may be expressed as the ratio of the range of temperature in the cycle to the highest absolute temperature. The lower temperature of the steam cycle is fixed by the tem-

perature of the available condensing water. The modern steam turbine can be designed to handle economically the steam volumes at the lowest average temperatures that may be secured with modern condensers, and these closely approach the leaving water temperatures. Hence, there is no longer any need for the consideration of binary vapor cycles for low-temperature operation.

The upper limit of temperature with saturated steam is fixed by its critical pressure. It does not seem desirable to operate at this upper limit, since such high pressures in the neighborhood of thirty-two hundred pounds per square inch involve expensive, heavy-duty equipment. Furthermore, unless one or more stages of reheating are employed, expansion from the critical pressure results in quite wet steam throughout the whole expansion with correspondingly low turbine efficiency. Increased superheat betters the cycle somewhat.

The possibilities of binary vapor cycles employing some other vapor than steam for the high-temperature range have been studied in the hope of thereby finding a means of securing higher efficiency than with steam alone. The high-temperature fluid should possess certain desirable qualities. It must be stable over long periods through the contemplated range of temperatures and should preferably operate at moderate pressures which would require only standard-weight equipment. Metals are becoming available that are suitable for higher temperatures than have been used in the past. Hence the possibilities of such binary fluids have an added interest.

Mercury has been used as the high-temperature fluid, and it possesses many of the properties most desired. Its first cost is high and its use has presented many construction problems to those who are developing the process.

The use of diphenyl oxide for the high-temperature binary fluid has been proposed by Doctor Dow in a recent paper. This substance appears to possess many of the desired properties, and engineers will study with interest all available and future data on its properties and performance under high and low temperatures.

The proposal to use an organic substance such as diphenyl oxide will suggest to many that it is quite probable that some other organic compounds may also prove suitable for use as binary vapors and may even be preferable to diphenyl oxide. Research for such other materials should therefore be stimulated.

Added interest in binary vapor cycles resulting from these discussions will direct further thought and study to this question and must ultimately benefit not only the engineering profession, but industry as well. Any who may have data on binary fluids should make these public so that the facts may serve as stepping stones in the advance of our knowledge of possible power developments.

Don't Lean on a License! It's a Poor Prop

JUDGING by their actions, many employers seem to be under the impression that operating engineers belong to the class of "skilled labor"—and not so very skilled at that. In New York City, for example, instances like the following are not uncommon:

The manager of a factory or large building advertises for a licensed engineer, specifying competence in a variety of specialties, such as steam power, refrigeration, elevator maintenance, etc. The applicant appears and makes the modest demand for fifty dollars a week. This is hardly a princely salary in any part of the country. In the metropolitan district of New York, with house rent far above the national average, it is about the bare minimum of existence for a man with wife and two children. Does the employer jump at the chance to obtain an experienced and conscientious engineer for this modest sum? In many cases he does not. Often as not he says, "I'm sorry, old man, but I have several applicants who will go to work tomorrow for forty dollars. Why should I pay fifty dollars when I can get an engineer for forty?"

Cheated by his own lack of vision, the employer thinks he is saving his firm ten dollars a week, or about five hundred a year. He does not grasp the elementary facts that the man he hires must handle a big investment in delicate machinery, the real depreciation of which is determined elsewhere than in the accounting department, that his carelessness or incompetence may be the direct cause of costly shutdowns, that his annual waste of fuel may easily run into thousands of dollars. As "economy" this is laughable—except for the engineer; it is no laughing matter for him.

The ray of hope in the situation, strange to say, lies in the very fact that engineers as a class are partly to blame for this state of affairs. The remedy is to a large extent in their own hands. They have unwittingly fostered the superstition that a license makes an engineer, that a licensed operating engineer is a definite standardized product. The licensing of engineers is highly desirable, especially from a safety viewpoint, but it is not a measure of a man's ability to produce power most economically. The employer must learn to choose his engineer as would any other department head—on the basis of capacity to produce dollars-and-cents results.

In this campaign of education the engineer himself must play the leading part. He must learn, more than he has in the past, to be a manager rather than a mechanic—and look the part. He must learn to talk and think in terms of production and unit costs. Only so will he come to command the respect and compensation which are rightfully his.

Turn Off the Heat

IF YOU were sitting in a room on a hot summer day and discovered the radiators running full blast, you would turn them off in the name of common decency and common sense or in fact any other name, common or uncommon, that happened to be handy. Why, then, stand for boiler and engine rooms rivaling Dante's Inferno? Of course no one expects a plant—unless it be a refrigerating plant—to hang out a shingle "twenty degrees cooler inside," but why in heaven's name burn fuel to keep hot in the dog days. Yet many do just that. Their plants are full of radiators in the shape of bare steam pipes, unlagged cylinders, naked heaters, etc.

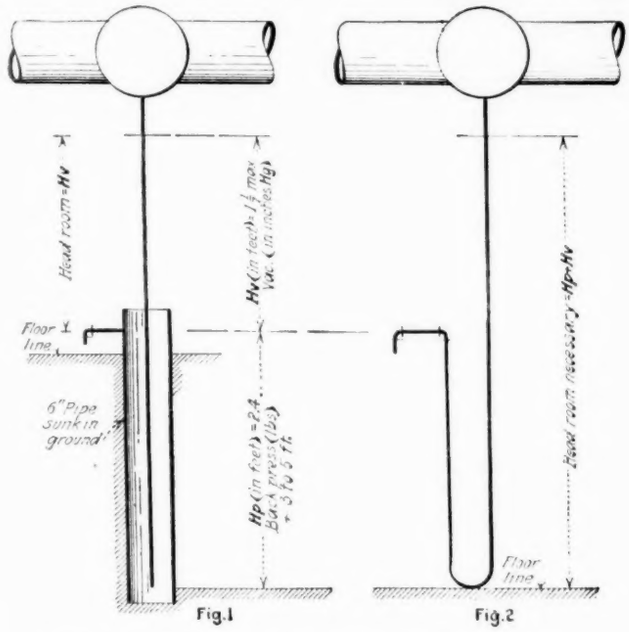
Good insulation is not so terribly expensive, nor is it hard to apply. A single summer's fuel saving will cover all the materials and labor needed for a first-class job. The comfort will be all velvet. If the owner balks at the small investment required, it is easy to figure how many tons of coal he can save in a year. And it shouldn't take much salesmanship to prove that the insulation of bare hot surfaces is a gilt-edge investment

Practical Ideas From Practical Men

Connecting Traps to Exhaust Lines for Pressures Above and Below Atmosphere

When the exhaust steam from reciprocating engines is used for heating or process work or is returned to the boilers as condensate, the elimination of solid oil particles and oily condensate from the steam is a matter of prime importance.

The evil effects of oil on the interior surfaces of a boiler are too well known to be enumerated, and the presence of grease and oily sludge in a heating system not only decreases its efficiency, but at times prevents its correct functioning by completely sealing up the discharge of radiators. The usual method of eliminating the oil is by means of an oil separator connected in the exhaust line, with a low-pressure trap or a U-column made up of pipe connected thereto. However, in the operation of a vacuum-return heating system during periods of light load or when the exhaust steam supply falls below the demands of the heating system, the pressure in the exhaust line will fall below atmosphere and will show a vacuum depending on the vacuum carried at the pump, line loss and other factors.



Figs. 1 and 2—Types of water-sealed U-columns used as traps

The engine will then be operating condensing, and the oil traps, if installed for non-condensing operation only, will cease to function and the oil and condensate will be retained in the exhaust and will then be lodged in the heating system or carried through to the heater and eventually to the boiler.

By taking cognizance of these facts and installing the oil traps so that they will function either above or below atmospheric pressure, the exhaust may be kept clear at all times.

Figs. 1 and 2 show water-sealed U-columns designed to work with pressures either above or below atmosphere. The distance *Hp* is that ordinarily used to take care of pressures above atmospheric, while the additional distance *Hv* will take care of pressures below atmospheric. Either arrangement is automatic, needs no attention and is applicable where the necessary headroom as indicated is available.

Fig. 3 represents a standard make of vacuum trap in connection with a U-column and Fig. 4 a combination of vacuum and low-pressure trap; these installations are applicable when the headroom is limited. Either combination is automatic in its operation, and as long as the pressure is above atmospheric, the low-pressure trap or U-column will function; when the exhaust pressure falls below atmospheric, the outer discharge check valve will close and the U-column or low-pressure trap will cease to function, the vacuum trap will then begin to fill up and automatically come into operation. Any one of the four arrangements shown will insure the disposal of the oil and condensate at all pressures above or below atmospheric, the particular layout being dependent on the headroom available for its installation.

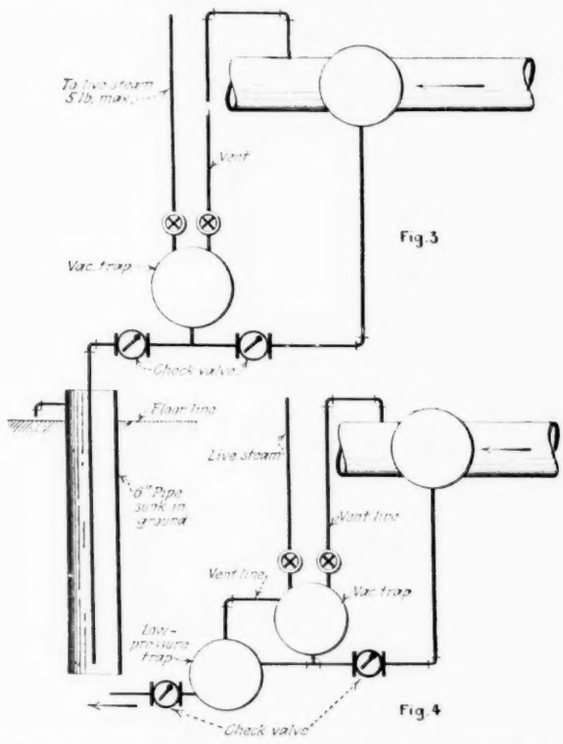


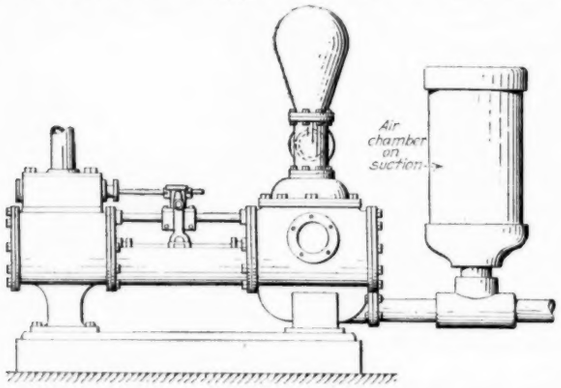
Fig. 3—Combination of vacuum trap and water-sealed U-column. Fig. 4—Combination of vacuum and low-pressure trap

Chicago, Ill. JULIUS BRODSKY.

Stopping Water Hammer in a Pump Suction Line

While checking up a water-turbine installation for the next season's run, I came upon a water-hammer problem in connection with a simplex steam pump in a nearby plant. In duplex pumps the overlapping of the strokes tends to even the flow in suction and discharge pipes to some extent and therefore has an advantage over a single-cylinder pump. The pump in question had a suction line with a total length of about 200 ft. and had a dozen or more bends. Sometimes fittings would break or a section of pipe would have a seam open.

In a single-cylinder pump the water in the suction line is started and stopped once each stroke, and the



Large chamber on suction pipe stopped the water hammer

faster the pump runs the quicker the water column has to be started and stopped. In this way a water hammer was started in the suction line in question, and the vibration kept up until something gave out. To remedy the trouble, I got a section of 10-in. pipe about 18 in. long, put a cap on one end and a reducer on the other, and tapped into the suction line with a tee, as in the figure. In this way a suction chamber was made that cushioned the flow and stopped the hammering.

Boston, Mass. M. B. THURSTON.

Low First Cost Should Not Exclude Other Considerations

In deciding upon the type of equipment to install when plant extensions are necessary or a new power plant is being built, undue consideration is given to first cost, with no thorough analysis of what the final operating cost will be. This occurs often in small and medium-sized plants, and often the old equipment is merely duplicated when the time comes to replace it.

Recently, a large textile plant installed a new boiler plant and an extraction-type turbine. Four 2,500-sq.ft. return-tubular boilers were decided upon, as the price for a given amount of heating surface in this type of boiler cost only half as much as would certain types of water-tube boilers. They feel that the water-tube boilers would have been an extravagance due to the increase in first cost and increased cost of setting, but some of the really significant considerations were left out entirely when making the decision. Here are a few advantages of the boiler that was rejected, which should be important enough to have swung the decision in its favor: The water-tube unit could be operated at 200 lb. pressure and its most economical load was around 150 per cent of rating and at all times delivered steam that was superheated 20 to 30 deg. In contrast to this, the fire-tube boilers could not be operated at over 150 lb. pressure, their most economical load was about 110 per cent of rating and the steam 98 per cent dry.

In view of these facts certain deductions can be made. First, since the water-tube boilers could operate economically at higher ratings, three 2,500-sq.ft. units would give the same capacity as four of the present 2,500-sq.ft. units, thus making the net cost of the water tube boilers only 50 per cent higher than the other type. Second, more power would be available from a pound of steam at 200 lb. pressure superheated 20 deg. or more, than at 150 lb. and 98 per cent dry. Third, the extraction pressure at the turbine was 40 lb. and the power requirements were 650 kw. About 30,000 lb. of steam per hour was bled, the total steam flow to the turbine being 33,000 lb. per hour.

Now since most of the power is secured by expanding steam from boiler pressure down to 40 lb., we can readily see the advantage of starting with steam at 200 lb., as the power output of the high-pressure stages is approximately 27 per cent greater at 200 lb. pressure superheated 20 deg. than under present conditions. This means that no steam need be exhausted into the condenser; in fact, the condenser and its auxiliaries could be dispensed with and a straight non-condensing unit could be used at the higher pressure and temperature. The cost of the non-condensing turbine would really be less than the bleeder unit with its necessary auxiliary equipment, so that the price differential is further reduced. The turbine steam consumption would be reduced by 3,000 lb. per hour and at least 1,000 lb. of steam per hour would be saved by eliminating the air and circulating pumps. Dyeing and bleaching were the principal processes carried on in this plant, and most plants of this type have a 24-hour load. It can be readily seen that the owner could afford to pay the higher price for the water-tube boilers since the operating costs would be reduced by at least $8,000 annually.

Even worse results are secured when some men, not well versed in the matter of combustion or boiler operation, attempt to revamp old boilers that are obviously unsuited for the duty they have to perform. For the sake of saving the cost of a new boiler, some plants try to increase the capacity of the old units by adding to the grate surface. One engineer had return-tubular boilers with a height of only 28 in. from the grates to the shell, and to secure additional capacity he had the grates extended one foot at the rear, increasing the grate surface about 17 per cent. The furnace volume was already too small and was the greatest drawback to high ratings, and the attempted cure aggravated this evil. Raising the boiler was the only economical method of securing greater output with the old boilers, as higher combustion rates combined with more efficient use of the coal burned would have given 25 per cent greater output with the same draft and grate surface. The extra operating cost for the ensuing two months would have paid for the cost of raising the boilers to give a 5-ft. furnace height, but the saving of about $5,000 in first cost of either a new boiler or correct setting of the old ones, looks so large to the company that they fail to see that this saving is wiped out in a few months by inefficient operation. A. F. SHEEHAN.

Springfield, Mass.

Comments from Readers

The Lecture Fetish

At the present time, when our engineering schools are apparently turning out more graduates than industry can absorb and the competition among candidates for "places in the sun" is daily growing more severe, the subject of technical training and training methods is full of interest. The editorial in the Feb. 2 issue on "The Lecture Fetish" raises one phase of the problem that strikes a sensitive chord among European students, for the lecture is an European institution and forms the backbone of the higher educational system in most countries in the Old World.

In France, beyond the baccalaureate examination, which corresponds, at least from the viewpoint of age, to our collegiate entrance exams, technical and scientific education consists almost entirely of lectures and laboratory work, with a great preponderance of the former. The textbook proper, as known in American universities, is practically non-existent. It is frequently replaced by an outline or summary of the lectures, handed out beforehand to the students in the form of mimeographed sheets. These outlines are hastily prepared, the figures are often drawn freehand, and the text, owing to the poor condition of the reproducing equipment, is sometimes barely readable. At the best, they constitute the lowest grade of textbook.

Compared to American educational practice, with textbooks full of carefully predigested subject matter and clear figures and illustrations that excite all the intuitive faculties of the student's mind, the European system spells little else than hard, persistent effort and drudgery.

Regarding the question of the relative value of the lecture system versus the textbook, there is, in my opinion, little room for competition between them, for one is the natural complement of the other. A lecture can hardly be efficient unless it is supported by a good textbook. In Europe, where labor-saving methods in the quest for knowledge are not in favor, the textbook is replaced by an abundant bibliography, to which the student is referred for information on the different views and opinions relative to the subject under treatment. He is expected to weigh the pros and cons and to "take sides" according to his lights. This system gives very good results, but it costs much both in time and in energy.

Considering the student's knowledge of his subject as a structure to be built up by his own efforts and those of his educators, the textbook should be the framework and foundation of the structure. Upon its solidity and reliability will depend the stability and reliability of the student's knowledge. It should cover impartially and as completely as possible the fundamentals of the subject. But it cannot be made a complete treatise in itself, first, because it cannot be kept up-to-date with the rapid evolution of science and technique; this can be accomplished only by the most careful analysis of periodicals, by daily contact with contemporary achievements, and by original research. Secondly, because, for lack of space, it cannot be made to include the number of illustrative examples necessary to establish firmly in the student's mind the link between theory and practice, which is the only means of forging a working tool out of what first appears to the student to be nothing but amorphous material.

Alone, the textbook is sterile. If the student's knowledge is to hold the spark of life, to have capacity for growth and progress which is the fundamental requirement of leadership, his textbook knowledge must be completed and fertilized by contact with a mind that has spent years of study and research on the subject and has itself become an element of growth and a motive force therein.

Of course there are lecturers and lecturers, and textbooks and textbooks. If the latter are not clear, concise, unbiased, yet complete as regards the fundamentals of the subject, they should be changed. If the lecturer is content "to drone out the substance of a textbook," he should also be changed.

A good textbook as a basis for a lecture course fills one purpose that is not usually given much consideration. It serves as a check on the lecturer. Most professors engage in some sort of research—all of them should. But when a man has given time and energy to research along specified lines, he will inevitably be tempted to linger in his lectures in some of these alluring side lanes that have absorbed his principal interest. This is dangerous, not only because it takes time that is needed to cover other branches of the subject, but because the lecturer's handling of original subject matter more or less a product of his own creative work is likely to be immeasurably superior to his treatment of the rest of the subject.

There is a rare fascination in following a master mind in its work along an unblazed trail. The lecturer's power over his audience will be particularly potent at this time. At the best, this will result in an exaggerated idea of the importance of this branch of the subject in the mind of the students. Inasmuch as this influence will be exerted on several hundred students yearly, its effect cannot be neglected. But the lecturer's teachings may also have positively evil results, for a research man may as easily be wrong as right in his conclusions, and they should not be passed on to the student until they have been thoroughly corroborated by others. The textbook will serve to restore the lecturer's sense of proportion and prevent him from wandering too far afield.

I fully agree with the editorial regarding the value of the recitation periods, as an aid and stimulant to, and a check on, the personal work and progress of the student. These have no place, however, in the higher education in France. It is claimed that they spoil the student and keep him in a state of immaturity; that higher students should be made to gather their own harvest. This may be so.

R. H. ANDREWS.

Paris, France.

Engineering and the Man

In the March 30 issue Professor Wood discusses Mr. Ogur's letter entitled "Engineering and the Man," which appeared in the Jan. 5 issue. According to Professor Wood, "The evidence at hand seems to indicate that industry is absorbing the present output of engineering graduates. The call for these men during the last four years has exceeded the supply three or four times over; industry has absorbed 100 per cent and would have taken at least twice as many if they were available." And, "All too few young men of college caliber know of the opportunities in mechanical engineering, and we need a larger number of the best high-school boys who are qualified and who desire to enter this field."

Many a man can recall how he was influenced by such propaganda as the foregoing, and finds himself after a number of years in "engineering," earning less than skilled mechanics working under his direction. Now, I know there is a "demand" for graduates in engineering. Perhaps the professor will tell his readers what salaries are offered by the demand(?). I know what salaries are offered, but I should like to see the professor supplement his letter by the information. It is not surprising that engineering students manage to find employment on graduation so long as the employer obtains men with technical training to fill positions formerly held by young men of little or no special training, and at salaries that would cause a feeling of shame were it not for the salving of conscience by the thought that he is enabling the young man to obtain some "practical experience." One needs but read the advertisements of manufacturers, municipal, state and governmental bureaus, and the employers of technical help generally, to wonder at the prevailing notion that the engineer is a highly paid and important member of society.

One of the most pitiful creatures in engineering today is the fellow working at the drafting table. This is trying and exacting work. Those who can, avoid the work, and in many cases develop into "sales-engineers," or "executives." The man who remains is still the "draftsman" although he may be responsible for all actual engineering making up the work engaged in.

Quite frequently we read the charge that engineers are narrow—provincial. "They know little of 'business'—they do not know law." It is well for progress that all engineers do not seek to "broaden" themselves by the acquisition of knowledge of business and law. The examples of this "broadened" engineer that have come to my notice were hybrids. They had, however, competent engineers at call, so the day is saved. By circumstances not entirely of their own making they have become "executives"; that is, employers of engineers. They are capable of "directing" large undertakings, yet could not, were they required to do the actual work, perform any but the simplest task in engineering. If you will but investigate, you will find that for the advances in the art we are not indebted to the engineering executive (he is too busy with business details) but to those having "a keen delight in intellectual conquest," who are generally underpaid.

A short time ago an eminent engineer, a man who has directed gigantic engineering projects, testified in a case resulting from the collapse of a structure, that the materials were at fault, when a tyro in engineering would have known that the method of loading was at fault. The situation is well described by a story that originated during the War. An engineer officer was conducting a school in engineering for a number of officers of the kind that was made on short notice in those days. These officers ranked from colonel down to the much "kidded" second lieutenant. The problem was the erection of a flagpole. The pole was lying on the ground together with the cement, sand and stone necessary for the foundation. Everything needed in the way of tools was available. The class was required to describe in detail just how the work should be done. The members of the class made more or less amusing attempts to solve the problem, and it finally came to a second lieutenant. He was asked how he would go about erecting the flagpole. He stiffened up in the manner popularly ascribed to second lieutenants and said, "I'd call my first sergeant and say, 'Sergeant, erect that flagpole and be snappy about it!'"

I have served in three campaigns in the military forces of the country in ranks from private to captain; have been in responsible charge of engineering work in civil life amounting to millions, and have had cause to be thankful for first sergeants and their equivalents in industry. A lot of engineering is being done by "first sergeants," and they get first sergeants' pay, too, which is the pity. As near as I can judge, a large part of "business" is this thing of getting people to work for a pittance, which probably explains the undercurrent of jealousy and feeling against Henry Ford, who has demonstrated that employers can pay living wages and still become immensely wealthy.

I have in mind two men working at "engineering," both graduates of universities—the one in mechanical-engineering and who has had twelve years' experience; the other in mining engineering, who has had fourteen years' experience. They each receive $175 a month! They are "boobs" you say? Well, they are not! They are men of fair ability. What would have been the course of these men when taking up the study of engineering had they known that a dozen years after graduation they would be receiving $175 a month?

Herbert Spencer believed that social inequalities had a way of correcting themselves; not by any conscious effort to that end, but by a kind of sifting that brought about an adjustment. This process is in operation on the problem discussed here; that is, the small remuneration of the engineer. The man who can do so is leaving the technical branches of engineering and his place is being filled by the less capable. The net result is that while the employer refuses to pay a fair salary to a competent man, he is actually paying much more to a number of the less competent and is not getting the services possible of the competent man. The average employer, not having had a thorough grounding in the details of engineering, cannot know what should be expected of help. While apparently incapable of so involved a process as the correlation of good pay and efficient service, he does comprehend what seems to him to be the immediate advantage attending small pay.

So long as subordinates in engineering consider themselves above organization for the purpose of bettering their condition, just so long will present conditions prevail. The alternative is a restriction of output of engineers, but this is a remote possibility in view of the forces operating to increase the output.

Los Angeles, Calif. C. O. SANDSTROM.

A Non-Corrosive Coagulant

I have read with a great deal of interest the first two articles on boiler feed-water purification by S. T. Powell and am looking forward to the remaining numbers.

In the second article, however, (*Power*, July 13), Mr. Powell has made a statement that is not entirely correct, and I mention it because it has to do with a new phase of water softening which has every indication of making past methods obsolete. The statement referred to occurs on page 51, where he says that "alum and other coagulating substances increase the permanent hardness of the water and may result also in materially increasing the corrosive properties of water that is treated with these substances." This is true with respect to alum and the other sulphate coagulants, but it is not true of all coagulants.

The real fact is that there is now on the market and has been for the last three years, a coagulant that does not increase the permanent hardness and that has no corrosive properties whatever on iron or steel, but actually is a protection to these metals. This coagulant is "sodium aluminate," used for coagulating purposes in connection with lime and soda softening systems, city filtration plants and internal treatment in boilers. Its use has many marked advantages over any other coagulant for these purposes.

Sodium aluminate is an alkaline coagulant of the chemical formula $Na_2Al_2O_4$. Being alkaline, it is non-corrosive and, of course, cannot increase the permanent hardness of the water. On the contrary, it softens the water as it coagulates, because it reacts on the calcium bicarbonates to form a calcium aluminate precipitate.

It may be of interest to know that in addition to the advantages mentioned previously as a coagulating agent, it actually speeds up the lime and soda-ash reactions in the softening plant, so that in practically all cases of cold-water softening the capacity of the treating plant is at least doubled, and in addition to that a much softer water is produced, with corresponding lower alkalinity and causticity readings.

Sodium aluminate is now being used in large quantities both for treating water externally in lime-soda softening plants and internally in boilers, and I feel sure that Mr. Powell will want to correct a statement in regard to coagulating substances, as well as devote some space in his succeeding articles to a chemical that is giving such a marked improvement over previous water-softening standards. I have written the foregoing not in an attitude of criticism, but with the idea of giving information that will be of benefit to the industries in general on water softening.

Chicago, Ill. H. A. KERN.

[The foregoing letter was referred to Mr. Powell, whose reply follows.—Editor.]

I have read H. A. Kern's letter concerning my statement in reference to the effect of coagulant in increasing the permanent hardness and the corrosive properties of water so treated.

Mr. Kern's contention that sodium aluminate does not increase the sulphate hardness of water or increase the corrosive properties of water so treated is correct. The present articles appearing in *Power* are abstracts of the various chapters of the book on feed-water treatment by the writer, which will appear at a later date. In the complete text I have taken up somewhat in detail the value of sodium aluminate for softening and coagulation of water and have indicated the differences between sodium aluminate and other coagulants, as has been pointed out by Mr. Kern.

It is regretted that in the abstracted article a statement concerning the effect of coagulant was not qualified so as to exclude sodium aluminate. This was purely an oversight, and the writer is glad to have an opportunity to correct the omission.

Baltimore, Md. S. T. POWELL.

Causes of Turbine Vibration

I have read the articles on "Causes of Turbine Vibration" by T. B. Wheaton and W. J. Lowe in the March 30 and June 8 issues, respectively.

I agree with Mr. Lowe and what he has to say on properly warming up the turbine prior to starting. However, I am of the opinion that he should have gone more into detail as to what is understood by properly warming up a turbine.

In my experience, I too have had trouble with machines vibrating, especially during the starting period, and by changing the method of warming up have eliminated trouble. I believe that in many cases engineers take it for granted that this vibration is inherited, since all of us have read of, or had explained, the critical speed of turbines in starting up, and many seem to believe that it is the critical speed of that particular turbine that causes the vibration, and when the machine is on the line for awhile, it disappears.

Many turbines are warmed up by slightly opening the throttle, first, of course, bringing the vacuum up to its proper point. It is at the slight opening of the throttle that, in my opinion, the trouble begins.

Just before opening the throttle, I think it is safe to assume that the temperature of the entire rotor is uniform. Now steam begins to issue from opening the throttle slightly. This steam rapidly condenses after it comes in contact with the upper sections of the wheels or rotors, which are, therefore, immediately heated to a higher temperature than the bottom sections. The heat so applied to the upper sections begins now slowly to conduct downward. Even with a warming up of 15 or 20 minutes, or longer, we have found that when the turbine comes up to two-thirds of its speed, it begins to vibrate. Slowly the vibration begins to disappear, through the wheels and shaft becoming evenly heated and hence again balanced.

It is my opinion that the uneven distribution of heat, as described, brings about an uneven expansion of shaft and wheels and temporarily bends the shaft, which in turn throws the rotor out of balance during that time.

For years we have started up our turbines in the following manner: After the vacuum is established, we slowly open the throttle, until the rotor begins to revolve. We then immediately begin to close the throttle and bring it down to a point where the rotor just barely keeps revolving, and after a couple of minutes the throttle will be opened a little more. When the machine is warmed up with the rotor slowly revolving, the heat distribution over the entire rotor is uniform, and hence equal expansion is maintained, resulting in the entire rotor remaining in proper balance. We have had no trouble with vibration during the starting period since this method was followed. A. J. GERMAN.

Waterbury, Conn.

Painting Pipe Lines

Several times I have read in *Power* of painting various pipe lines different colors so as to aid in distinguishing them, and have wondered if this scheme is of much practical value.

Certainly, no one ever confuses a steam line with a water line, and on air and vacuum lines there are usually gages and connections of various kinds that enable one to differentiate between them at a glance. A well water and city water line may be confused when in the vicinity of each other and possibly warrant the use of different colors on them, but in general I believe the character of the pipe line and the fittings used are sufficient to enable the engineer to distinguish between them.

But suppose that, in spite of this, the pipes are painted different colors. Does this solve the whole problem? It is true that you will be able to name the contents of any pipe at a glance if you do not forget what the colors mean, but is that what the engineer usually desires to know? Is it not the real problem to say what this steam or water line feeds or what will be affected if it is shut off, rather than whether it is a steam line or a water line?

I once saw hung in different sections of a chemical plant blueprint diagrams of the pipe lines, by which the men were able at a glance to trace any line and see just what it fed. The valves were numbered for record purposes, so these numbers were carried on the prints and served as landmarks in congested places. In many places this factory was piped with high- and low-pressure steam, well and city water, compressed air and vacuum, gas and two kinds of oil, yet the engineer could always say which pipe was which, but it was difficult for him to say where a certain pipe went or what it fed until the diagrams were consulted.

It seems to me that the saving or convenience the coloring scheme affords the engineer is not worth the time and material necessary for its installation.

Newark, N. J. RAYMOND L. DREW.

Why Boiler Tubes Burn Out

The following is a reply to a criticism by Alex. M. Ormond in the April 27 issue, of my article of Jan. 12, "Why Boiler Tubes Burnt Out." Issue is raised by Mr. Ormond on a number of points, on all of which I still maintain my original contentions.

Regarding my claim that burning occurred first, followed by the formation of a slight blister, to repeat in my exact words, I said "burning, or *rather* wasting occurred first." Note that the term was changed to wasting for it was recognized that the word burning in this case did not convey the proper and full meaning intended. Burning is always oxidation, but in the case in question the oxidation was due to chemical action, namely, the decomposition of ferric and ferrous sulphates to form FeO and Fe_2O_3. This is observed by optical examination by the fact that the burned mass has a spongy, porous appearance.

Mr. Ormond contends that steam in contact with the iron is sufficient to keep it cold enough to prevent burning. Therein he errs so obviously that it does not seem necessary to go into detail. He also says that the fact that this "soot" was of a greenish color and moist means nothing. Again he errs. These very observations were responsible for raising the suspicions of the investigator, caused him to direct his attention to this deposit and led him directly to the logical solution as advanced. First of all, the accumulation cannot be called "soot." It is a greenish deposit. As a matter of fact the composition of the deposit was not reasoned, it was determined by actual analysis, for in all scientific work guesses cannot be entertained and the investigation covered by the article was of an entirely scientific nature.

Also the moisture, as correctly stated by Mr. Ormond, could not have been present when the tubes were under fire. Such being the case, the moisture must have been imparted after removal from the furnace, and if obtained from the air, as in this case, the material is said to be hygroscopic, a property possessed by relatively few materials, soot not being one of them.

It is further claimed by Mr. Ormond that only gases are present in the furnace, whereas my contention is that of all these gases the sulphuric-acid gas, because of its high condensation temperature, is liquefied on the relatively cold surface of the boiler tube. What is unreasonable about this?

The reason why the lower rows are subject to failure is also explained in my previous article. This is due to the fact that failure is caused by a combination of corrosion and fusion of the products of corrosion. Heat is required for fusion, hence the lower row, the hottest, is the one were tubes invariably fail.

The failure explained in my original article would not be so marked with oil carrying 0.5 per cent sulphur as compared with oil of 3 per cent or more sulphur content. Failures are due to various causes, only one, and in my opinion a very prevalent one, being explained by the theory advanced.

With reference to his statement that the water in the boiler in which tube failure occurs is always of a higher concentration than that contained by the other boilers, does not the fact of high density of the water point to a greater proportion of soluble salts? In this case then, the water in the other boilers has deposited more of its solids as scale, and if scale were the prime cause of the burnout, would it not be more marked in the case of the boilers with low-density water?

By means of the theory advanced in my article, it is readily understood why the lower rows of tubes are the ones that invariably fail. The lower rows are most favorably situated to aid fusion and, as explained, it is this fusion of the external salts of iron that corrodes the tubes to the breaking point.

Mr. Ormond is emphatic that the tube burn-outs are due to internal causes. For his information I will mention that the plant where the investigation was made always experienced some losses, but not to the same extent as when the tubes were cleared of scale, and further, since the investigation reported on was made, the plant in question has had no reported tube loss. This, I think is significant. I would also refer Mr. Ormond to an article in the Sept. 15, 1925, issue by W. H. Burton, in which it was brought out that the tube cleaned externally, but allowed to remain scaled internally did not fail, whereas the one cleaned internally and allowed to remain dirty externally did fail. This also is significant, but altogether explainable by my contention and theory.

New York City. GEORGE C. REINHARD,
Chief Chemist, Feedwaters, Inc.

Intercrystalline Cracks in Riveted Seams*

By H. KRIEGSHEIM†

THE author maintains that intercrystalline cracks in boiler seams are fully explained by the action of prolonged high total stresses, and that high internal stress, when present, is due to unsuitable mechanical or thermal treatment of the material during manufacture or operation. The type of cracks under discussion is defined and it is shown that brittleness and intergranular weakness, due to improper treatment of the material, have been recognized as long as low carbon steel has been in general use. Observations from experimental work and investigations of failures within the last 30 years are cited.

Factors Influencing Boiler Failure

In analyzing a failure, five items must be considered: (a) The composition of the metal; (b) the work done on it during manufacture of the plates and fabrication of the boiler; (c) the temperature to which the material has been subjected during fabrication and operation; (d) the effect of time, and (e) the feed water.

The crystal structure and composition of steel are discussed. The suggestion has been made to increase the carbon content of boiler steel. While low carbon steel is more ductile, it has a greater tendency to crystal growth, which weakens the steel. Increased carbon content will decrease the tendency to crystal growth and provide a safer steel. The manufacturers prefer a low carbon steel, since it facilitates fabrication. Abnormally distributed "cementite" is often found in the steel when intercrystalline cracks occur.

If internal stresses are kept within reasonable limits, boiler material will stand such internal stresses plus the externally applied stresses without trouble. Of course, plates—and particularly those finished at low temperatures, and dished and flanged heads—should be annealed. Material injured by shearing and punching must be removed. Hammering of plate ends and the use of drift-pins must be avoided. The seams must be designed to remain tight when the boiler is subjected to the unavoidable variations in stress caused by the pressure and temperature changes of usual boiler service. For this purpose it is necessary that the plates be laid up metal to metal and be tightly pressed together by the rivets. Otherwise, when the seam is loose, the plates slide over each other, and without friction between the plates to help transmit the load, the entire load is transmitted through the rivets, causing localized high stress at rivet holes. Excessive calking of a loose seam will not cure the original defect. On the contrary, it will only make it worse, since it causes bending stresses in the plates and opens the interstices between the plates farther.

The snapping off of rivet heads is ascribed to the bad effect of improperly heating the rivets, to vibrations during driving of rivets due to looseness in the joint and to deformation of the material at blue heat.

Effect of Temperature

If a metal structure is unequally heated, the cooler portions will be subjected to tensile stress and the hot portions to compression. The stresses may be sufficient to cause deformation and give rise to cracks within the structure. The appearance of fire cracks in boiler joints has been explained in this way.

The firing-up of boilers without proper water circulation causes great differences in temperature in the boiler structure. Particularly large deformations are produced in mud drums of inclined water-tube boilers, if cold water is trapped therein. No seam made up of thick plates should be exposed to flue gas. The effect of temperature in the development of crystal growth, which weakens the material considerably, is discussed.

The Effect of Time

Several workers have presented evidence that metals crack when subjected to prolonged or internal stresses for long periods of time without any chemical action, and the theory is upheld that the prolonged application of high stress causes a flow of the viscous intercrystalline cement resulting in intercrystalline cracks.

The Effect of Feed Water

This section of the paper presents evidence against the theory that caustic soda is the main and necessary cause of intercrystalline cracks in boiler seams. It is now recognized that in addition to caustic soda, heavy stress is necessary to cause the cracks, but, says the author, no definite line has been drawn indicating what the contributing effect of the caustic soda actually was in any practical case. It has been claimed that caustic soda will concentrate within seams, but there should be no interstices in a properly fitted seam, and no proof is forthcoming of the possibility of concentration in seams. Moreover, as long as hydrogen developed from the caustic soda is considered the embrittling element, the evidence proves that the production of hydrogen is not dependent upon the presence of caustic soda.

The author refers to the recent work of Parr and Straub (abstracted in *Power* for June 29, 1926) but does not comment in detail on their statements, which had not been published at the time this paper was presented.

The author then refers to the list of failures submitted to the A.S.M.E. Boiler Code Committee, illustrating this phenomenon. He divides the failures into groups, corresponding to the various types of boilers used, and points out that the fractures occurred in definite places for each type of boiler at which the stresses may approach the breaking point.

Since caustic soda is present in 99 out of 100 boilers, and since many boiler waters contain little sulphate, it is easy to find cases of failure where caustic soda was present or where the ratio of sulphate to carbonate was small. However, cracks showing all the characteristics of so-called hydrogen embrittlement have developed in cases where caustic soda was absent, and also in places (outside of seams) where concentration beyond that of the boiler water cannot be assumed.

Conclusions

The more recent investigations which trace intercrystalline fractures in steam boilers to parts that have been overstressed, point away from the theory that the chemical action of caustic soda alone will cause the failures.[1]

The author concludes that caustic soda is not necessary to explain the failures and in support of this cites failures of boilers and other steel structures, such as shafting, bridges, etc., where caustic soda was absent.

Speaking to a meeting of boiler and pressure vessel inspectors, the author appealed to them to make thorough examination of each actual failure and to submit a full report. The activity of inspectors along these lines will not only supply the missing data from a statistical point of view, but will bring about co-operation of all those interested in improvements and thus enlarge our understanding of the conditions that cause intercrystalline cracks in riveted seams.

Throughout the paper the author cited specific instances with numerous illustrations and extended quotations. The paper is an excellent summary of evidence supporting the fact that intercrystalline cracks are caused, in some cases at least, by prolonged or internal stress, with no chemical accelerating agents.

---

*Abstract of paper read at the Fourth Annual Meeting of the National Board of Boiler and Pressure Vessel Inspectors, Chicago, Ill., May 25, 1926, by S. B. Applebaum, assistant technical manager, The Permutit Co., New York. The complete paper is obtainable from C. O. Meyers, Secretary of the Board, Columbus, Ohio.

†President, The Permutit Co.

[1]Attention is directed to the recognition of the importance of stress. In 1917 Professor Parr (Bulletin 94, Univ. of Ill.), said: "The evidence seems to show that the embrittling effect of sodium hydroxide on steel is due to the evolution of hydrogen and the absorption by the steel of the hydrogen in the nascent state." Earlier in the same Bulletin he remarks that "emphasis should be laid upon the fact that much more remains to be done." His recent report presents the results of such additional investigation, and he concludes that "the results indicate that two conditions must be present simultaneously to produce the embrittlement effect; first, the stressing of the metal above the yield point; and second, the concentration of sodium hydroxide to a point which is in excess of 350 g. per liter." (20,000 grains per gallon.) Professor Parr's further discussion of this point in *Power* for Aug. 10, 1926, p. 215, is illuminating.—Editor.

News in the Field of Power

Flywheel Explosion Wrecks Power Plant When Governor Belt Slips

Wet Steam Primary Cause of Speed Variation—Plant Operated by King Paper Mill—Damage May Total $150,000—None Seriously Injured

DESCRIBED as one of the most violent accidents of its kind occurring in recent years, a flywheel explosion took place at about 10:30 p.m., Wednesday, July 21, at the plant of the King Paper Co., of the Allied Paper Mills, Kalamazoo, Mich. At the time the engine room was without attendants, as the engineering shifts were changing, therefore no serious personal injuries were sustained.

Giving Normal Service

The engine was a cross compound, having 20-in. and 38-in. diameter cylinders, with 48-in. stroke, and it carried an 18 ft. flywheel. Its operating speed was normally 85 r.p.m. It had been in operation under usual conditions for several days, its service being continuous throughout the twenty-four hours of the day.

Immediately prior to the accident, those going off and those coming on duty were congregated in the washroom adjoining the engine room, through the door of which more or less of the equipment was visible.

It is said the attention of the watch engineer going off duty was attracted by an unusual noise in the engine room, which was thought to have been coming from the low-pressure cylinder. He, with the engineer coming on duty, ran toward the engine, which at that time had attained considerable speed, with the main drive belt in place. An attempt was made to operate the governor unhooking device by the use of the starting bar, but was unsuccessful, although the governing mechanism shows the results of six or seven blows which he gave it. The engineer started to close the throttle, but was cautioned against doing so on account of the anticipated failure of the main drive belt and the wheel.

Section Flew Quarter Mile

The men ran from the engine room into the boiler room just as the main drive belt broke; and the time between the failure of the belt and the failure of the wheel has been estimated as two or three seconds.

Of the twin type, the wheel was constructed of two parts, with independent hubs, spokes and rims, but with provision for bolting the rims together, so as to form a single wide rim, double-armed wheel, the face of which was 52 in. in width. The rim of each section was cast in two parts, having a flanged and bolted rim joint. Sections of the wheel, some of which weighed approximately a ton, were found more than one-quarter of a mile from the plant. Those containing the joint indicated failure took place in the rim of the wheel close to the joint, but the joint bolts were of such strength that they did not fail, and in fact showed very little stretching as the result of the stresses set up by the overspeeding.

Boilers Blown Down

Outstanding facts appear to be that the boilers primed to an extent following each blow-down period, at intervals of eight hours. The venturi chart shows the increased water consumption between 10 and 10:20 o'clock, just a few minutes preceding the accident, indicating without doubt that the boilers were blown down at that time. The priming, which frequently had resulted, necessitated the use of forced lubrication, to enable the dashpots on the high-pressure side to seat properly. The steam valves on the low-pressure side had a positive cutoff.

It is probable that the quality of steam furnished to the engine following the blow-down of the boilers, caused the speed of the engine to decrease, as it is said those operating some of the machinery noticed a drop in speed, so relieved some of the machines of their load, which of course would react on the engine to the extent that it would be inclined to speed up, as it undoubtedly did, and would be beyond the governor control if the governor belt slipped, as it would do if saturated with oil.

Governor Belt Failed

It is said the governor was rotating at about normal speed, and at about normal plane, when the effort was made to operate the unhooking device, which, in connection with the governor idler belt, would prevent the governor from dropping to lowest position until disconnected, unless the governor belt should break. The governor did not reach its highest position, as the safety cams were so adjusted steam would have been prevented from reaching the cylinders. The governor, valve mechanism and governor belt were found in position and intact following the accident.

It seems logical to conclude that the engine slowed down, was relieved of a part of its load, and then speeded up so rapidly that the governor belt failed to grip the pulleys, which placed the engine beyond the governor control, resulting in attaining a speed sufficient to disrupt the flywheel.

Room Equipment Damaged

The frame of the engine was damaged, as were also various other parts of the engine room equipment, including the steam pipes, which were broken off, discharging the contents of the boilers into the engine room. Although no one was seriously hurt, some of the attendants received burns and slight injuries,

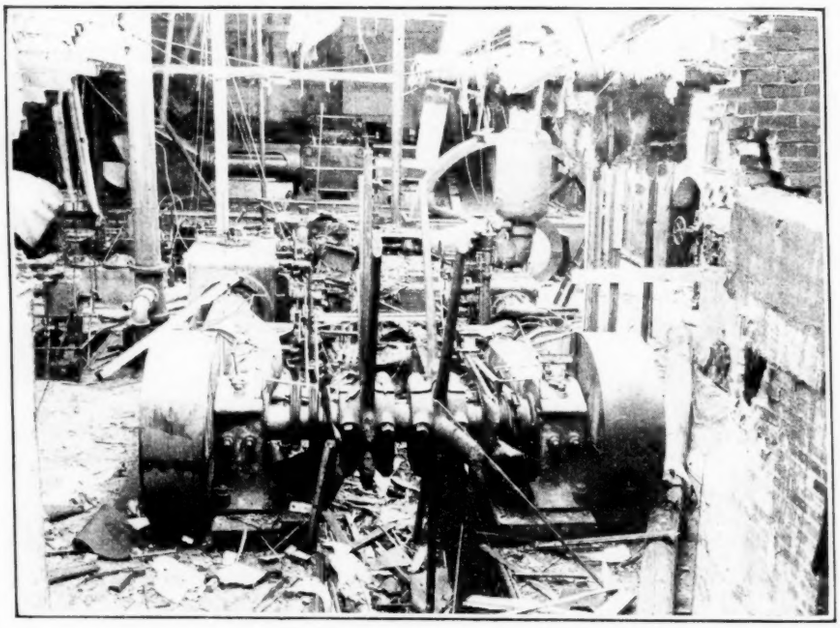


Fig. 1—Shows a near view of the wheel end of the engine that failed. In the middle background is seen the crosshead of a tandem-compound engine. Far back is the wreck of another

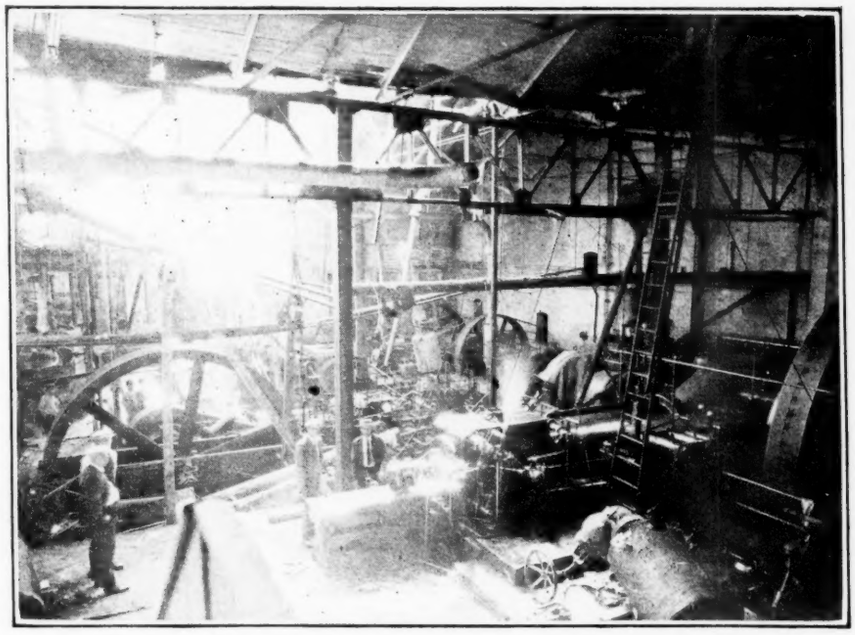


Fig. 2—Here is a comprehensive view of the plant from the opposite direction. The 1,500-hp. cross-compound engine is in the foreground

in attempting to shut off the main steam valves in the boiler room, which, together with the rest of the plant, was in darkness.

A close-up view of the wheel end of the engine which failed is shown in Fig. 1. In the middle background can be seen the cross-head of a tandem-compound engine, the low-pressure cylinder of which was damaged by flying parts of the wheel, while in the distant background will be noticed a 1,500-hp. cross-compound engine, which likewise was in the path of the flying parts of the wheel, but which suffered only minor injuries, consisting principally of broken throttle, separator and governing mechanism.

DAMAGE EXCEEDS $100,000

Fig. 2 gives a view of the plant from the opposite direction, with the 1,500-hp. engine in the foreground. It is said a very thorough investigation was made, but, as is frequently the case, there were several conflicting statements, and those in a position to discover just how it happened, did not have time to do so when the conditions were developing.

Some estimates have placed the total damage as between $100,000 and $150,000, which probably includes the loss in production and the use and occupancy loss, due to the closing of the plant, as the result of the accident.

Yosemite Power Plans Dams To Increase Output

Contemplating the construction of reservoirs and power houses costing $5,000,000, the Yosemite Power Co., with offices in San Francisco, filed an application with the state division of water rights to divert 175 cu.ft. per second from the south and middle forks of the Tuolumne River in Tuolumne County, Calif.

The project involves the construction of two dams and three power houses for the development of 66,304 potential horsepower.

U. S. Water Power Maps Show Promise for Washington

Power possibilities of North and South Forks of Skokomish River, Dosewallips and Hamma Hamma Rivers, and Lilliwaup Creek in the State of Washington, are indicated in maps now made available by the Department of the Interior, through the Geological Survey, according to a statement issued by the department.

These maps are the result of surveys made by E. E. Jones, hydraulic engineer of the Geological Survey, and are said to be very valuable for use in making preliminary estimates of power resources of the streams covered by the survey.

Most of the larger streams of the Olympic Peninsula, in northwestern Washington, have their sources on the glacial slopes of the Olympic Mountains within the boundaries of the Mount Olympus National Monument and the Olympic National Forest. In connection with its general study of the water resources of the public domain, the Interior Department, through the Geological Survey, has begun a survey of these streams.

The area is covered with a heavy growth of spruce, fir, hemlock and cedar, and the principal industry at present is lumbering. But as the streams have a well-sustained flow and a very heavy grade, they constitute a valuable power resource. The city of Tacoma has recently dedicated its 50,000-hp. development on Skokomish River, known as the Lake Cushman plant, and plans have been considered for a second plant to have a capacity of 90,000 hp. between Lake Cushman and the Hood Canal. Eventually, many other streams will be developed.

In 1925, Mr. Jones made plane-table surveys of the North and South Forks of Skokomish River, Dosewallips and Hamma Hamma Rivers, and Lilliwaup Creek. The resulting maps are drawn on a scale of two inches to the mile, and the contour interval is 50 ft. As they are not based on precise levels nor tied into known geographic positions, the maps may be subject to some error of both location and elevation, but they present a record of the fall of the streams and the topography of the banks and therefore have considerable value for use in making preliminary estimates of power possibilities. Copies can be procured at a nominal price from the district office of the Geological Survey, 404 Federal Bldg., Tacoma, Wash.

French Question Tax Aid for Power Development

As was to be expected, the bill recently presented before the Parliament of France, and reported in the June 8 issue of *Power*, which proposes to raise a 5 per cent tax on the sale of electrical energy for lighting, for the purpose of subsidizing hydro-electric developments, has met with violent opposition from several quarters.

The center of this movement appears to be the densely populated industrial districts around the coal-mining centers of the North and Northeast, along the Belgian border. The malcontents claim, probably with some reason, that such a tax would fall heavily on these regions, whereas the benefits they would derive from hydro-electric power would be questionable.

Owing to the proximity of the large mine-mouth steam plants which, according to the French superpower project, are to be distributed throughout the coal-mining districts, and the great distance between the latter and the large centers of water power, it is claimed that the power needs of the northern industrial centers will be almost exclusively supplied by the steam plants.

This is probably true in a measure, particularly during the lengthy construction period, when practically no water-generated power will reach the North. However, when the 150,000-kva. network is eventually completed, it seems likely that, during at least two-thirds of the year, enough hydro power will reach these regions to supply an appreciable part of their demand.

This attitude appears somewhat short-sighted. It is certain that the greatest benefits derived by the country in general from the complete development of its water-power resources will consist less in a material reduction in power rates than in the general improvement in the economic situation through better manufacturing facilities, and a vast improvement in the transportation system resulting from electrification of all the railroads. The productive capacity of the country will be greatly increased thereby. But the principal beneficiaries of these advantages will unquestionably be the large industrial centers.

It does not seem probable that the opposition of the Northern coal-mining districts will prove a serious menace to the bill, if it finds support in the rest of the country. For the industrial region about Paris is amply sufficient to counterbalance the North, and has everything to gain from the development of water power.

Insull Interests Buy To Form New Company

The Victor Emanuel power holdings, which include the Southwest Power Co. in northwest Arkansas, were sold to the Insull interests of Chicago, according to word received Aug. 3.

The Southwest Power Co. owned electric light plants at Eureka Springs, Springdale, Rogers, Fayetteville, Siloam Springs, Harrison, in Arkansas, as well as in many Oklahoma cities.

About four hundred plants are said to have figured in the sale. The new company will be known as the National Electric Power Co.

Universal Craftsmen Stage Exhibits and Powwow

Large attendance marked the 24th annual convention of the Universal Craftsmen Council of Engineers held this year Aug. 3 to 7 at Milwaukee, Wis.

Aside from the convention sessions, which dealt principally with subjects and problems of a local nature, interesting features consisted of a luncheon and trip through the plant of the Nordberg Manufacturing Co., inspection of the Lakeside Power Plant, with particular attention to the new section now under construction, an entertainment and smoker given by the exhibitors and a closing banquet at the Milwaukee Athletic Club held Aug. 6.

Exhibits occupying, in all, 208 booths, displaying power equipment and supplies of every description, were staged in the auditorium of the club. Convention meetings were so scheduled that visiting engineers were given ample opportunity to study all the products shown.

Officers elected for next year are: Louis J. Cudbird, Toronto, Canada, Grand Worthy Chief; Walter H. Daman, Springfield, Mass., thus becoming Past Grand Worthy Chief; W. Charles Clark, Cleveland Heights, Ohio, Grand Assistant Chief; Thomas H. Jones, Cherrydale, Va., Grand Secretary; John L. Obrien, Chicago, Ill.; Grand Treasurer; J. R. Hass, Chicago, Ill., Grand Warden; George A. Lambert, Brooklyn, N. Y., Grand Guard. The convention in 1927 will be held in Buffalo, N. Y.

Highest Dam Will Be Built on Owyhee Project

Perhaps the highest dam ever designed by the reclamation service is to be built in Oregon on the Owyhee irrigation project, Oregon and Idaho, to be known as the "Hole-in-the-Ground" dam, but work on this structure cannot begin until there is a further appropriation by Congress. This dam is to rise to a height of 355 ft., 6 ft. higher than the Arrowrock dam on the Boise project, which today is the highest structure built in this country for irrigation purposes. The Hole-in-the-Ground dam, which will impound 695,000 acre-feet of water, is estimated to cost slightly more than $6,000,000.

Construction Held Up

Out of the money appropriated for the Owyhee project last session nothing can be done on the dam proper, as most of the amount will be necessary to construct a road to the dam site to carry materials and supplies.

Construction work on the Vale project was delayed because the Warm Springs district, which has entered into a contract with the Secretary of the Interior and which had that contract approved by the court, has now asked that the contract be amended.

Aside from the money set aside for drainage on the Vale project, there is $300,000 available, which will be spent in constructing the main canal.

American Superpower Seeks To Amend Application

The American Superpower Corp. is seeking to amend its application for a preliminary permit covering its proposed project on the St. Lawrence River. The application was filed January 10, 1923, but never has been acted on by the Federal Power Commission, which has suspended action on all St. Lawrence applications pending an agreement with Canada for the further development of the resources of the boundary streams.

Amendment submitted proposes four alternate schemes of development. One plans a 27-ft. development at Ogden Island and a 54-ft. development at Barnhart Island. The second plan is for a 75-ft. development at Barnhart Island, with a regulating dam only at Ogden Island. A third plan suggests an 85-ft. dam at Barnhart Island, only. The other alternate plan calls for a dam 85½ ft. at Barnhart Island, together with a plan for navigation.

All the plans contemplate maintaining the 14-ft. navigation now available. The locations were adopted, however, with a view to possible future extension of the controlling depth to 35 feet.

French Scientists Gather At Scientific Exhibition

The French Association for the Advancement of Science has opened its yearly congress at Lyon and, for the first time in its history, has been able to combine this session with an exhibit of scientific and industrial equipment pertaining to the different phases of their activities.

Interest of the power field will go mainly to Group C of the exhibit, covering the generation, distribution and applications of gas and electricity. The exhibit includes, among many other phases of industrial activity, an historical sketch of the development of gas lighting and of the different uses of electricity.

Spanish Company Planning More Power

Dam construction made possible by capital increased from $5,000,000 to $7,000,000, is being carried on by the Sevillana de Electricidad Power Co. on the Cala River, near Sevilla, Spain.

The new power plant will have a capacity of 124,000-hp., and will supply the provinces of Savilla, Cadiz, Huelva, and Malaga, according to Commercial Attache Charles H. Cunningham at Madrid.

Pratt School Schedules Diesel Engine Course

A course on Diesel engines for operating engineers is scheduled on the curriculum of the fall term of instruction at the Pratt School of Applied Science, Brooklyn, N. Y.

Consisting of ten lectures, the course can be attended for $25. For an additional laboratory course a like price will be charged.

Group attending this year's convention of the Universal Craftsmen Council of Engineers held Aug. 3-7 at Milwaukee, Wis.

Obituary

Prof. Edgar Kidwell, mechanical engineer and consultant for the Kidwell Boiler Co., Milwaukee, Wis., died July 9 at his home in Berkeley, Calif. A graduate engineer of the University of Pennsylvania, he taught at that university as instructor of mechanical engineering, later becoming professor of mechanical and electrical engineering at Michigan College of Mines. As engineer he served in various capacities for several industrial and machinery manufacturers. As a contributor of many technical articles for a number of engineering journals, Professor Kidwell was the author, among other papers, of "Wooden Beams, Columns and Shafts," "The Efficiency of Built-up Wooden Beams," "Tests of Stirling and Babcock & Wilcox Boilers," "Stirling, a Book of Steam for Engineers," "Specifications and Drawings for Setting of Boilers," "The Kidwell Two-Flow Ring Circuit Boiler." He was an active member of the National Association of Stationary Engineers.

Business Notes

The Magnolia Metal Co. has removed from 113 Bank Street to 75 West Street, New York City.

The Chicago Pneumatic Tool Co. announces the appointment of H. W. Dellon, formerly with Durant & Co., New York City, as sales engineer at Philadelphia.

The Eagle Oil & Supply Co., of Boston, has been appointed distributor for Quigley Furnace Specialties Co., Inc., of New York, covering eastern Massachusetts and Rhode Island, for all Quigley products including Hytempite, acid-proof cement, Quigley Refractory Gun, and Triple-A protective solutions, etc., which will be carried in stock.

The Carborundum Co., manufacturer of abrasive and refractory materials, Niagara Falls, N. Y., announces that George R. Rayner, vice-president in charge of sales, will continue as head of that department. Statement is also made of the appointment of Williams MacGregor and S. F. Courter as Mr. Rayner's assistants. Both Mr. MacGregor and Mr. Courter will carry on titles of general sales managers, each being in charge of a sales division, and will succeed in this work the late William Welsh Sanderson.

Trade Catalogs

Multi-stage Centrifugal Pumps—The Warren Steam Pump Co., Warren, Mass. Bulletin 203 deals with the multi-stage, balanced-type centrifugal pump. The design and arrangement of the impellers are such that the end thrust is reduced to a minimum, it is stated. The two-, three- and four-stage styles are shown in cross-section. Specifications are enumerated.

Diesel Engines—Catalog 34 describes the Anderson type KD Diesel engine manufactured by the Anderson Engine & Foundry Co., Anderson, Ind. This oil engine is a heavy-duty Diesel of two-stroke-cycle, cold-starting, mechanical-injection type. To insure long life, the parts on the Anderson Diesel run unusually slow. It is claimed that the Anderson uses the cheapest grades of fuel oil.

High Pressure Boiler Drums—The Roland Steel Co., Inc., sole distributor for the Press & Walzwerk Co., 114 Liberty St., N. Y. This catalog deals with seamless steel forged drums of square, rectangular and round tubing for sectional headers, mud drums, etc. The physical properties of forged chambers at various temperatures and tensile strength are tabulated. Sections and drums entire are pictured.

Coming Conventions

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Regional meeting at Richmond, Va., Sept. 27-30.

Association of Edison Illuminating Companies. Chateau Frontenac, Quebec, Sept. 27-Oct. 1. P. S. Millar, 80th St. and East End Ave., New York.

Empire State Gas and Electric Association. Lake Placid Club, N. Y., Sept. 30-Oct. 1. C. H. B. Chapin, Grand Central Terminal, New York.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. Convention at Atlantic City, begins Sept. 14. Erroneously announced as Sept. 6-11. Annual conventions and exhibitions of state associations are scheduled for the following dates: **New York State Association,** Wilmer T. Meinzer, 3626-215 Place, Bayside, Long Island, N. Y. Postponed from June 11 to 12, at Troy, N. Y., to Sept. 12-13 at Atlantic City, N. J. **New Jersey State Association,** S. G. Dalrymple, 111 Hutton St., Jersey City, Convention at Atlantic City, Sept. 12; **Pennsylvania State Association,** Frank J. McCarron, 3647 North 11th St., Philadelphia, Convention at Philadelphia, Sept. 12-13.

Carbon Products—The United States Graphite Co. has just issued Catalog B-4 covering the USG motor and generator brushes. All the standard grades, coatings, and sizes are noticed. A table of brush characteristics and suggestions for the elimination of brush troubles are included.

Uniflow Steam Engine—The Farnsworth Co., Harrisburg, Pa. This is a comprehensive bulletin on the Harrisburg dual-clearance uniflow engine. The major part is devoted to an outline of the action of the valve gear. Cross-sections in color of the cylinder, showing the several events during a piston stroke, help the reader to understand the operation of this engine. Authenticated tests on several engines are added features.

Standard Building Clearances for Whiting overhead electric traveling cranes—The Whiting Corp., Harvey, Ill. Bulletin No. 176. The clearance figures given are based on Whiting standard construction, viz., notched girders and M.C.B. type end trucks. This data should be of special benefit to engineers in the designing of buildings or rooms in which cranes are to be used. Electric Drop Pit Table is the subject of a broadside which shows results obtained in actual use.

Nickel Cast Iron, Data and Applications—The International Nickel Co., 67 Wall St., New York City. Bulletin No. 201 considers the properties and applications of nickel and nickel-chromium cast iron. A number of suggestive illustrations are given in this two-page leaflet. Improving gray cast iron with nickel is the subject of Bulletin 202. This paper, prepared by the development and research department of the company, takes up, among other problems, the improvement and stabilization of machinability, "machine hardness," wear-resistance, elimination of porosity and internal shrinkage, and the reduction and regulation of chill.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Aug. 9 1926
Pool 1	New York	$2.50@$2.75
Smokeless	Boston	2.28
Clearfield	Boston	1.65@ 1.90
Somerset	Boston	1.75@ 2.00
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	1.40@ 1.75
Pittsburgh	Pittsburgh	1.60@ 1.90
Pittsburgh gas slack	Pittsburgh	1.20@ 1.30
Franklin, Ill.	Chicago	2.35@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.15@ 2.35
West Ky.	Louisville	1.10@ 1.35
S. E. Ky.	Louisville	1.40@ 1.75
Big Seam	Birmingham	1.75@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1	New York	1.65@ 3.50
Buckwheat No. 1	Philadelphia	1.85@ 2.75
Birdseye	New York	1.25@ 2.00

FUEL OIL

New York—Aug. 12, light oil, tank-car lots; 28@34 deg. Baumé, 6c. per gal.; 36@40 deg., 6⅜c. per gal. f.o.b. Bayonne, N. J.

St. Louis—Aug. 7, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 5.8c. per gal.; 38@40 deg., 7¼c. per gal.

Pittsburgh—Aug. 3, f.o.b. local refinery; 30@34 deg., fuel oil, 5¾c. per gal.; 36@40 deg., fuel oil 6½c. per gal.

Dallas—Aug. 7, f.o.b. local refinery 26@30 deg., $1.75 per bbl.

Philadelphia—Aug. 6, 27@30 deg., $2.52@$2.58 per bbl.; 13@19 deg., $1.59 @$1.65 per bbl.

Cincinnati—Aug. 9, tank-car lots f.o.b. local refinery, 24@26 deg., Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—Aug. 9, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.30 per bbl.; 26@30 deg., $1.35@$1.40; 30@32 deg., $1.55

Boston—Aug. 9, tank-car lots f.o.b. 12@14 deg. Baumé 4½c. per gal.; 28@32 deg., 6c. per gal.

New Plant Construction

Ark., Marianna—City soon takes bids for waterworks system, including pumping equipment, filtration plant, etc. Estimated cost $100,000 to $120,000. T. H. Allen, 840 Bank Commerce Bldg., is engineer.

Conn., Hartford—Arrow Electric Co., 103 Hawthorne St., is having tentative plans prepared for the construction of a power plant addition, on Capitol Ave. Estimated cost $10,000. Engineer not selected.

Idaho—Bureau Reclamation, Dept. of Interior, Denver, Colo., will receive bids until September 1 for 1 hydraulic turbine to deliver 3,500 hp. when operating at a 47 ft. head; one 3,000 kva. generator; four 1,000 kva. transformers, switching apparatus; and four 33,000 v. oil circuit breakers for Minidoka Power Plant, here.

Ill., Chicago—Hooper & Janisch, 879 North State St., Archts., are receiving bids for the construction of 12 and 15 story apartment, at 527 Cornelia Ave. for Leopold & Hicks, 1569 Howard St. Estimated cost $750,000. F. A. Randall, 160 North La Salle St. is engineer.

Ill., East St. Louis—Atlas Block Co., 29th and Missouri Sts., is in the market for 25-10 hp. horizontal boiler.

Ind., Anderson — E. F. Miller awarded contract for the construction of bank and office building on 10th and Meredian Sts., to L. Coleric, Indianapolis, $500,000.

Ind., Indianapolis—Bd. Trustees of Indiana State School for Blind, awarded contract for the construction of power plant, laundry, etc. at school, 75th St. and College Ave. here, to Brown and Mick. $104,226.

Ia., Dubuque—City plans installing pumping equipment, etc. at Eagle Point Pump Station. Estimated cost $37,000. J. Stuber is city clerk.

Ia., Newton—City is having plans prepared for developing new source for waterworks system, including pump station, etc. Estimated cost $90,000. L. Higgins, 420 Security Bldg., Des Moines, is engineer.

La., Lake Charles—City will receive bids until September 1 for waterworks, including pump, etc., for Lake Charles Dock Board, at Walnut Grove.

Mass., Dorchester (Boston P. O.)—City, Transit Dept., Beacon St., Boston, is having plans prepared for the construction of 1 story power house on Harrison Sq. Estimated cost $800,000. E. F. Springer, 1 Beacon St., Boston, is engineer.

Mass., Needham—Bd. Selectmen, awarded contract for the construction of waterworks including pumphouse and equipment to C. A. Zappe, 5 Lindale St., Dedham. Estimated cost $15,000.

Mass., Worcester—Main Street Corp., c/o A. W. Johnson, Madison Ave., New York City, Archt., awarded contract for the construction 5 story theatre and office building, at Main and High Sts., here, to J. D. Harrison Constr. Co., 285 Madison Ave., New York City. Estimated cost $900,000.

Miss., Ocean Springs—Local Syndicate c/o Jones, Roessle & Olschner, Archts., Maison-Blanche Bldg., New Orleans, awarded contract for the construction of 9 story hotel to Cornet-Casey Co., Chemical Bldg., St. Louis, Mo. Estimated cost $1,500,000.

Mo., Buffalo—City will receive bids until August 25, for waterworks extensions, including 75 g.p.m. motor driven deep well pump. Russell & Axon, 112 McDaniel Bldg., Springfield, is engineer.

Mo., Nevada—Missouri Pacific R.R. Co., Railway Exchange Bldg., St. Louis will build boiler house, etc. here with own forces. Estimated cost $125,000. E. A. Hadley, Railway Exchange Bldg., is chief engineer.

Mo., St. Louis—Moloney Electric Co., subsidiary American Brown Boveri Co., 165 Broadway, New York City, awarded contract for the construction of 1, 2 and 3 story transformer plant, on Kingshighway Northwest, here to Hercules Construction Co., Wainwright Bldg. Estimated cost $1,000,000.

Nev., Carlin—City, A. H. Berming, clk., is in the market for Diesel engine and equipment, including 2 hp. electrical driven centrifugal water pump, electric generator, switchboard, etc.

N. J., Jersey City—The 2801 Blvd. Co., B. Carminsky, Pres., is having plans prepared for the construction of 5 story apartment at Sip and Hudson Aves. Estimated cost $750,000. Shape, Bready & Peterkin, 285 Madison Ave., New York City, are engineers and architects.

N. Y., New York—American News Co., 9 Park Row, awarded contract for the construction of an 18 story office building at 9-15 Park Pl. to Cauldwell-Wingate Co., 381 4th Ave. Estimated cost $3,000,000.

N. Y., New York—G. Berenson Investing Co., 165 Bway., plans 27 story hotel at Madison Ave. and 59th St. Estimated cost $2,000,000. Engineer and architect not selected.

N. Y., New York—Department of Parks, Arsenal Bldg., Central Park will soon receive bids for the construction of Theodore Roosevelt Memorial Building, at Central Park West and 79th St. Estimated cost $2,500,000. J. R. Pope, 542 5th Ave., is architect. E. E. Seelye, 101 Park Ave. is engineer.

N. Y., New York—S. Meyer, 41 East 72nd St., is having plans prepared for the construction of 15 story apartment on East 19th St. Estimated cost $700,000. E. Levy, 441 Lexington Ave., is architect.

N. Y., New York—Owner, c/o Walker & Gillette, 128 East 37th St., Archts. is having plans prepared for the construction of 16 story, apartment at 79th St. and Park Ave. Estimated cost $1,000,000.

N. Y., New York—Simon & Hartstein c/o E. Roth, 119 West 40th St., Archt., are having plans prepared for the the construction of 15 story apartment at Lexington Ave. and 63rd St. Estimated cost $3,000,000. D. M. Oltarsh, 36 West 44th St., is engineer.

N. Y., New York—Sojour Realty Co., J. Silver, Pres., c/o Deutsch & Schneider, 35 Maiden Lane, Archts. and Engrs., is having plans prepared for the construction of 20 story hotel at 351 West 42d St. Estimated cost $1,500,000.

O., Bowling Green—Bd. Trustees, Bowling Green State Normal School, is having plans prepared for the construction of boiler house and laundry here. Estimated cost $40,000. H. D. Briggs, Ohio-Hartman Bldg., Columbus, is engineer.

O., Cleveland—City will receive bids until August 20, for the construction of superstructure of Kirkland Pumping Station. L. A. Quayle, City Hall, is engineer.

O., Cleveland—Cleveland Railway Co., Hanna Bldg., J. H. Alexander, Vice-Pres., is having plans prepared for the construction of boiler house, etc., at West 117th St. and Lorain Ave. Estimated cost $200,000. D. W. Morrow, 4500 Euclid Ave., is engineer.

O., Cleveland—Park Drop Forge Co., F. L. Bail, Secy., East 79th St., awarded contract for the construction of 1 story boiler house addition, on East 79th St. to G. A. Rutherford Co., 2527 Prospect Ave. Estimated cost $40,000.

O., Dayton—Wilber Wright Hotel Co., c/o Schenk & Williams, Archts., Mutual Bldg., is having plans prepared for the construction of 14 story hotel, at 2nd and Ludlow Sts. Estimated cost $2,500,000.

O., Hamilton—G. C. Mitchell, Director of Service, will receive bids until September 15, for two 3,000 kw. steam turbines, 2 condensers, 50 kw. steam turbine exciter set, three 500 hp. boilers, three 1750 kw. Diesel engine generating units.

O., Moraine (Mail West Carrollton)—Delco Light Co., 3rd National Bank Bldg., awarded contract for the construction of power house to Danis-Hunt Construction Co., 1st and Webb Sts. $100,000. Owners in market for 7,000 hp. power unit.

Okla., Seminole—Plans election August 20, to vote $25,000 bonds for the construction of waterworks extensions, including pumping equipment, etc. C. E. Waits, Wewoka, is engineer.

Okla., Tulsa—H. C. Tyrell, Mid Continent Bldg., plans 10 story office building, at 5th and Boulder Sts. Estimated cost $600,000.

Pa., Danville—Board of Trustees, State Hospital A. V. Rishel, Pres., will receive bids until August 26, for furnishing and installing boilers, stokers, etc., at State Hospital, here. Stewart & Jellett Co., 1200 Locust St., Philadelphia, are engineers.

Pa., Philadelphia—L. M. Lifted, Jefferson Bldg., is having preliminary plans prepared for the construction of 9 story apartment, at 63rd and Walnut Sts. Estimated cost $1,500,000. Stetler & Dysher, Jefferson Bldg., are architects.

Pa., Philadelphia—Provident Life Insurance Co., 4th and Chestnut Sts., awarded contract for the construction of 4 story office building at 46th and Market Sts. to Turner Construction Co., 1700 Walnut St., on cost plus basis. Estimated cost $3,000,000.

Texas—Texas Power Co., National Bank of Commerce Bldg., awarded contract for the construction of hydro-electric plant at Seguin, 3 power houses and dams on Guadalupe River between Seguin and New Branfels, etc., to Sumner Sollitt Co., National Bank Commerce Bldg. $1,200,000.

Tex., Crystal City—Texas Central Power Co. will build power plant here. Estimated cost $60,000. Work will be done by day labor. Owners will install 720 hp. Diesel engine unit.

Tex., Dalhart—Dalhart Water Co. is having preliminary plans prepared for waterworks improvements, including pumping equipment, etc., to replace fire loss. Estimated cost $15,000. Private plans.

Tex., Dallas—American Ice Co., c/o C. E. Kennemer, Pres., 4901 Cole Ave., will build an ice plant at 3307 Lemmon Ave., including 80 ton motor driven ice plant unit. Estimated cost $150,000. Private plans.

Tex., Point Isabel—Valley Electric & Ice Co. will build 1 story, 50 kw. power plant and ice station. Estimated cost $60,000. Work will be done by day labor. Owners will purchase complete machinery.

Tex., Houston—R. S. Sterling, Postal Dispatch Bldg., awarded contract for the construction 40 story hotel on Texas Ave., between San Jacinto and Carolina Sts. to D. Hall, 522 Cotton Exchange Bldg., on cost plus basis. Estimated cost $6,000,000.

Tex., Stephenville—City is receiving bids for the construction of waterworks improvements, including pumping machinery, 300 hp. engine, etc. Estimated cost $15,000. H. B. McAllister, 1315 12th St., Waco, is engineer.

Tex., Wichita Falls—New Ice Co., c/o W. McKemie, Sr., W. McKemie, Jr. and R. H. Roach, having plans prepared for the construction of an ice plant, at 601 Burnett St. Estimated cost $100,000.

Wis., Berlin—Wisconsin Power & Light Co., H. R. Smith, Dist. Mgr., is receiving bids for the construction of power plant, including new switchboard, etc. Estimated cost $40,000. Botch & Lippert, Gay Bldg., Madison, are engineers.

Wis., Big Falls—Wisconsin Power & Light Co., Gay Bldg., awarded contract for the construction of power house, including generator and switchboard, etc., to L. E. Myers & Co., Monadnock Bldg., Chicago, Ill. Estimated cost $50,000.

Wis., Gillett—City, P. Nygard, Clk., will receive bids until August 19, for constructing deep well, with pump and motor to produce 500 g.p.m. McMahon & Clark, Menasha, are engineers.

Wis., Janesville—Wisconsin Power & Light Co., Gay Bldg., Madison, is having plans prepared for the construction of 1 story, central hydro-electric plant, with two 300 kva. generators, two 350 hp. turbines, etc. Mead & Seastone, Journal Bldg., Madison, are engineers.

Wis., Mendota—State Board of Control, Capitol, Madison, A. W. Bagley, Secy., is in the market for refrigeration machinery, and equipment for state hospital for insane, here.

Wis., St. Nazianz—Salvatorian Fathers, awarded contract for the construction of 2 story boiler house and laundry to W. W. Oeflein, 86 Michigan Ave. Estimated cost $60,000. E. Brielmaier & Sons Co., 432 Broadway, Milwaukee, Archts., will purchase boiler, etc.